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TECHNICAL REVIEW

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Compatible Higher-Definition Television

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21 Compatible Higher-Definition Television

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Introduction

by J. B. Sewter

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There is a growing feeling among many broadcast engineers that new technological developments are likely to make the current television system look rather outmoded within the next few years. They are aware of the formidable range of prototype high-definition television (HDTV) equipment already developed in Japan - equipments which have been used to demonstrate the technical feasibility of producing television programmes in true high-definition video.

They are also familiar with the trends and predictions in Very Large Scale Integration (VLSI) technology which suggest that, for several years to come, the 'performance' of digital VLSI chips - in terms of increasing numbers of gates per chip and higher clock rates - will more than double each year, while the cost will remain fairly constant.

Developments in cable and communications satellite technology reinforce the view, commonly expressed, that we are on the threshold of a revolution in broadcasting - a revolution which will generate a 'step function' in television system performance and bring the 'cinema viewing experience' into the home. Related to this view of the imminence of revolutionary change is a growing pressure towards the adoption of world standards for HDTV production; the implication being that such a world standard would be similar to the 1125/60/2:1 system with 5:3 aspect ratio proposed and demonstrated by NHK (Nippon Hoso Kyokai - the public broadcasting organisation in Japan) and Japanese industry (demonstrated also by CBS of the United States).

It is argued that the problems of broadcasting such a standard, which requires about five times the bandwidth of current television systems, can be reduced by adopting digital modulation and by implementing sophisticated digital processing at the transmitter and the receiver. By such means it is hoped to reduce the r.f. bandwidth requirements to be equivalent to those of only two conventional television channels.

There are many sceptics among broadcasting engineers who take an opposing view. They argue that the existing technical standards and services give the public what they want and they question whether new and totally incompatible services will be economically viable. They point to the scale of investment in existing receiving equipment and to the 'step function' in cost that will be required to purchase the new receiving equipment and displays. At the extreme, this view sees no possible justification for any change in technical standards. Some of the sceptics, however, would welcome change towards improved technical standards provided that such changes were applied step-by-step, thus building upon the foundation of the existing system. They are aware that the advancing technolog. can be used to enhance the performance of the current system in a compatible and evolutionary way, and they feel that such an approach is the more realistic.

Perhaps what is not realised sufficiently, however, is just how far such compatible developments can go towards achieving the required objectives of providing pictures suitable for viewing on large-screen displays of wider aspect ratio.

For example, in the context of direct broadcasting by satellite (DBS) in Europe, it can be argued that there is sufficient potential in the 625-line system to permit compatible transmission of considerably higher-quality signals through a single 27 MHz WARC '77 r.f. channel. A significant step forward has already been taken in the UK with the adoption

of the C-MAC transmission format, which does not employ a colour subcarrier, and which keeps the luminance and colour-difference components completely separate. In addition to providing improved 625-line pictures with a 4:3 aspect ratio, further processing may be incorporated to provide wider aspect ratio pictures suitable for viewing on large-screen displays. This, coupled with improvements in resolution, including sequential scanning (otherwise known as progressive scanning), could provide an enhanced viewing experience approaching that which has been demonstrated with the proposed NHK incompatible HDTV standard.
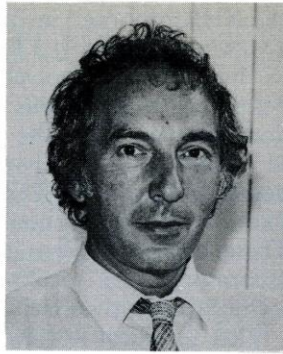
For the majority of source material the picture resolution potentially available from this 625-line compatible system at a viewing distance of around 3.8H should be equivalent to that obtainable from the NHK proposed incompatible HDTV standard at a viewing distance of 3.3H.

The processes involved in such compatible higher-definition transmissions will become practicable for domestic use by the inclusion of field stores in domestic receiving equipment. Predicted developments in VLSI technology suggest that this is likely to become economically viable by about 1990. These processes have already been studied in the laboratory, and results to date suggest that the technical objectives will almost certainly be achieved.

This Technical Review includes a discussion of the relative advantages of the two approaches to HDTV broadcasting. Ways are described in which the MAC system could be used to achieve wider aspect ratios and higher definition while maintaining compatibility with the 625-line television system and the WARC '77 plan.

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Why Non-compatible High-Definition Television?

by T. J. Long

Synopsis

The various requirements for providing 'high-definition' television are summarised, together with the limitations of existing television systems.

The conventional approach to high-definition television is to increase the number of lines of the transmission system, with a consequent increase in bandwidth requirements, and incompatibility with existing systems.

The advent of direct broadcasting by satellite (DBS) using the MAC format introduces the possibility of further enhancements to give a compatible 'extended-definition' system. This would be capable of providing much of the improved quality of high-definition systems, yet without introducing incompatibility with either the 625-line format or current proposals for DBS.

THE REQUIREMENTS FOR A HIGH-DEFINITION TELEVISION SYSTEM

Although not defined precisely, it is generally accepted that 'high-definition television' (HDTV) implies a television system which can bring much of the 'cinema viewing experience' to the home. An HDTV system should provide pictures of wider aspect ratio and of increased spatial resolution suitable for viewing on larger screen displays at distances appropriate to the home environment.

The requirements for such a system have been the subject of many studies throughout the world, but perhaps the most extensive studies of recent times have been those made in Japan in the laboratories of NHK.[1] Although some of the results obtained by NHK are the subject of continuing debate, it is generally accepted that their published work has established the basic requirements for HDTV. The following discussion draws heavily on the NHK investigations. The main requirements for HDTV are summarised under the headings:

— Picture Area, Aspect Ratio and Viewing Distance
— Spatial Resolution
— Temporal Resolution
— Display Requirements.

Picture Area, Aspect Ratio and Viewing Distance

The results of extensive NHK subjective tests[2] suggest that the optimum viewing distance for high-resolution large-screen pictures in the home is in the range 3H to 4H (where H is the picture height). At these viewing distances the preferred aspect ratio is around 5:3. For still pictures only there is a

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preference for somewhat larger picture areas (viewing distance less than 2.5H) and wider aspect ratios (up to 2:1). For pictures involving considerable movement, however, viewing at the closer distances tends to cause dizziness and fatigue, and the preferred viewing distance increases to around 4H. These results (obtained at an actual viewing distance of 2.5 m) are consistent with cinema viewing practice in the United States, where a survey has shown that the average 'centre of cinema' viewing distance is 3.3H.[3]

Spatial-temporal Frequency Response of the Eye

For a high brightness and contrast ratio, the eye can resolve frequencies up to 60 cycles per degree (c/deg) spatially and 70 Hz temporally.[4] A further factor is that spatial and temporal frequencies are traded; i.e., the spatial frequency response of the eye decreases with increased temporal frequency.[1] To a simple approximation, therefore, the contour of the upper limit of resolution for the eye could be as illustrated in Fig. 1. For a viewing distance of four times the picture height (4H), a spatial frequency of 60 c/deg
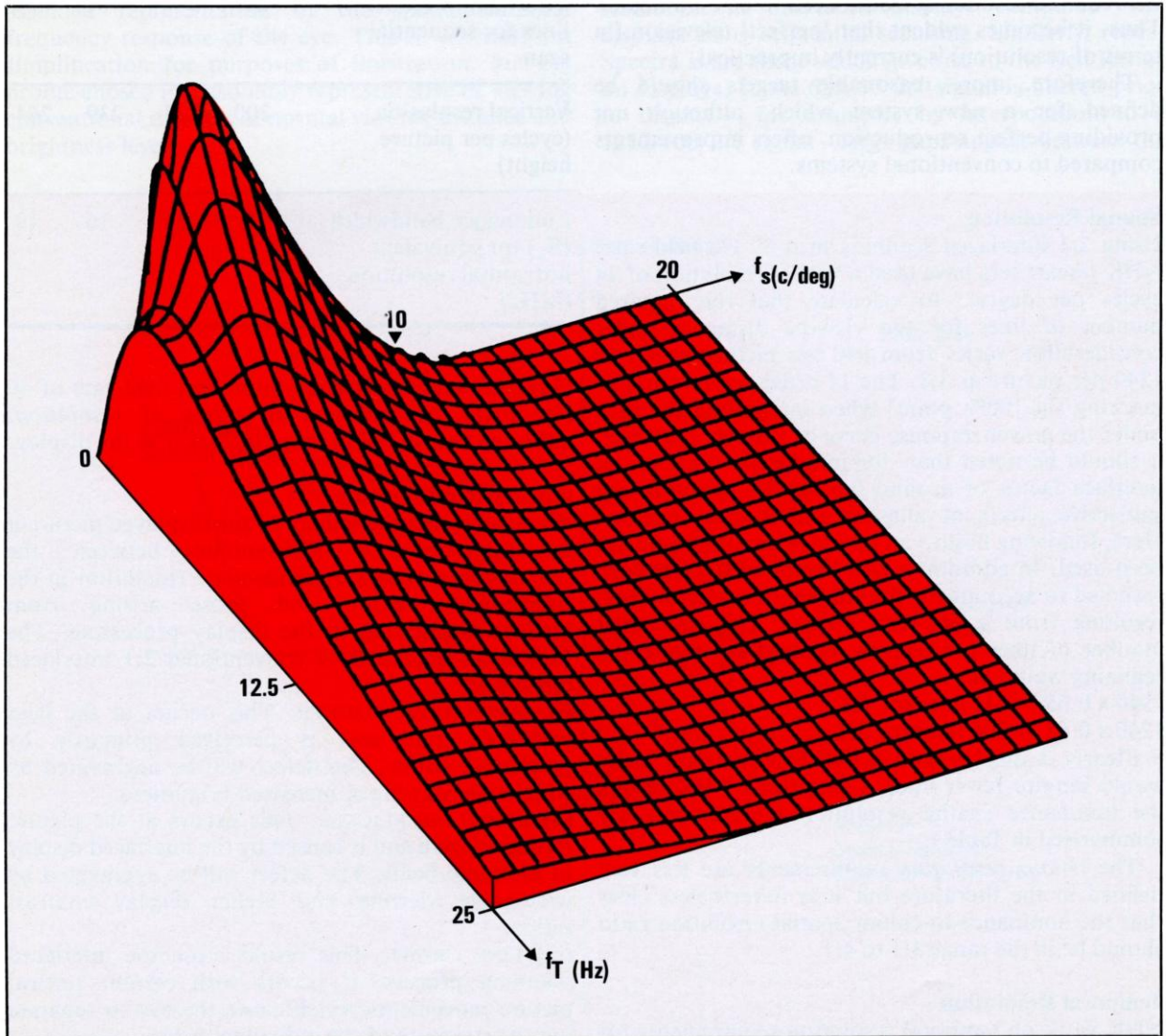

Fig. 1. A possible contour for the upper limit of resolution in the eye, in terms of spatial frequency (f_s) and temporal frequency (f_T).

represents a vertical frequency of 855 cycles per picture height (c/ph). For 3H, the equivalent vertical frequency is 1135 c/ph. In terms of vertical resolution, therefore, it would appear that a scanning standard with 1710 active lines would be required for the transmission of 'lifelike' pictures at a viewing distance of 4H, and 2270 active lines for 3H. In order to accommodate the temporal resolution of 70 Hz, a field rate of 140 Hz would be required. However, if the tracking of motion by the eye is taken into account, then the requirements for temporal resolution change; to achieve perfect reproduction, the required resolution would need to be even higher. Thus, it becomes evident that 'perfect' television (in terms of resolution) is currently impractical.

Therefore, more reasonable targets should be defined for a new system which, although not providing perfect reproduction, offers improvements compared to conventional systems.

Spatial Resolution
Using 2:1 interlaced scanning at a 60 Hz field rate, NHK researchers have used a spatial resolution of 14 cycles per degree[5] to calculate that the required number of lines for the viewing distances under consideration varies from 940 per picture at 4H to 1240 per picture at 3H. The 14 c/deg figure arose as marking the '90% point' when integrating the area under the power response curve of the eye. However, it should be noted that, for interlaced scanning, an interlace factor of around 0.6 applies owing to the subjective effects of aliasing and display defects.[6] Here, following Fujio,[5] an interlace factor of 0.65 has been used. In addition a Kell Factor of 0.7 has been assumed to account for the subjective resolution loss resulting from a line-scan display. The equivalent number of lines per picture required for sequential scanning would be:

940 x 0.65 = 611 lines for 4H
1240 x 0.65 = 806 lines for 3H.

Clearly, a display with a Kell Factor nearer unity would require fewer lines. Using these NHK results the luminance spatial resolution requirements are summarised in Table 1.

The *colour resolution* requirements are less well defined in the literature but it is nevertheless clear that the luminance-to-colour spatial resolution ratio should be in the range 3:1 to 4:1.

Temporal Resolution
NHK work on temporal resolution requirements for HDTV is less well reported in the literature, but

TABLE 1: VARIATION OF LUMINANCE SPATIAL RESOLUTION REQUIREMENTS WITH VIEWING DISTANCE

	4H	3.5H	3.3H	3H
Viewing distance (multiples of picture height)				
Number of lines per picture (2:1 Interlaced Scan)	940	1060	1125	1240
Equivalent number of lines for sequential scan	611	689	731	806
Vertical resolution (cycles per picture height)	200	225	239	264
Luminance bandwidth (B_L) for equivalent horizontal resolution (MHz)	11	14	16	19

Hayashi[7] suggests that an interlaced field rate of 40 Hz might be sufficient in terms of *resolution*, although clearly not in terms of flicker at the display.

Display Requirements
When assessing the quality of the displayed picture it is important to differentiate between the impairments caused by inadequate resolution in the transmitted picture and those arising from inadequate filtering in the display processing. The four main defects of a conventional 2:1 interlaced display are:

(i) LARGE-AREA FLICKER. This occurs at the field frequency rate and is perceived primarily by peripheral vision. The defect will be aggravated by wide-angle viewing at increased brightness.

(ii) INTERLINE FLICKER. This occurs at the picture frequency rate and is caused by the interlaced display of alternate fields. The defect will be aggravated by wide-angle viewing and higher display contrast ratios.

(iii) LINE CRAWL. This results from the interlaced scanning process. It occurs with certain vertical picture movements which cause the eye to separate out the structure of the individual fields.

(iv) LINE STRUCTURE. This defect is readily seen on

high-resolution displays with reduced spot sizes and will be aggravated by increased viewing angles.

The fundamental causes of these subjective impairments to the displayed picture are the signal sampling processes inherent in the television scanning mechanism.[8,9] These processes generate repeat spectra at harmonics of the field and line repetition rates. This is illustrated in Fig. 2 which shows the spectra generated by 625/50/2:1 and 1250/100/2:1 interlaced scanning plotted on the two-dimensional vertical-temporal frequency plane.

Superimposed upon the plotted spectra is an assumed representation of the spatial/temporal frequency response of the eye. This is, of course, a simplification for purposes of illustration, but the profile chosen is reasonably representative of viewing conventional displays at normal viewing distance and brightness levels.

In the illustration, the display defects of the 625/50/2:1 system result from the sensitivity of the eye to the repeat spectra labelled A, B, and C. The subjective effects of particular repeat spectral areas falling within the eye's response are related to the visibility of known display defects in the following way:

Repeat Spectra $\begin{cases} A \text{ — large-area flicker} \\ B \text{ — line structure} \\ C \text{ — interline flicker and line crawl.} \end{cases}$

It is almost certainly repeat Spectra C which are responsible for the apparent reduction of vertical resolution in interlaced displays compared with displays using sequential scanning. Similarly, repeat Spectra B are those which give rise to the Kell Factor on displays. If the 625/50/2:1 signal is filtered prior to display - for example, by interpolation to a 1250/100/2:1 signal - large gaps appear between the
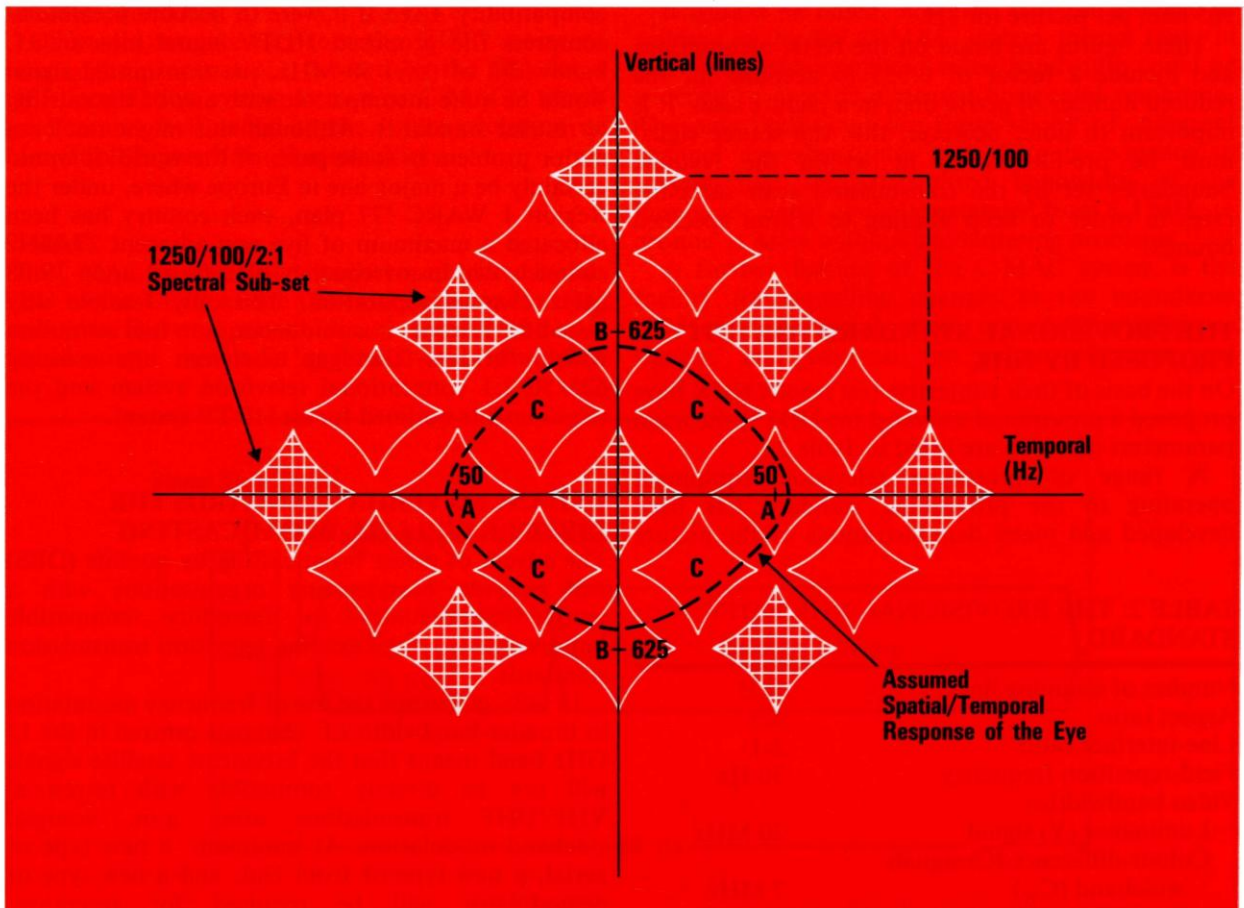

Fig. 2. Two-dimensional frequency spectra for 625/50/2:1 and 1250/100/2:1 interlaced-scan displays.

repeat Spectra so that all or most of the unwanted frequency information now falls outside the eye's response, thus allowing the full resolution of the transmitted image to be perceived.

The effect of interpolating to other display formats may also be seen from the diagram. In a 625/100/1:1 display, for example, effects associated with areas A and C would be greatly reduced, thus leaving B (line visibility) as the main display impairment.

The use of interpolating filters to provide higher scan rates in the display makes it possible to envisage a television system which conserves transmission bandwidth by employing lower scanning rates for the transmitted signal than for the display. For example, if a display rate is used such that none of the interlace or Kell Factor effects disturb the eye, then from Table 1 it follows that the required number of lines in transmission are:

428 lines per picture for 4H
565 lines per picture for 3H.

These figures are based on the NHK assumptions and include a factor of 0.935 to account for the reduced number of *active* lines in a picture scan. It is important to note, however, that the source signal must be pre-filtered to fit within the Nyquist boundaries set by the transmission scan sampling rates in order to keep aliasing to within specified bounds.

THE PROVISIONAL STANDARD FOR HDTV PROPOSED BY NHK

On the basis of their subjective test results NHK have proposed a provisional standard for HDTV, the main parameters of which are listed in Table 2.

A range of prototype television equipment operating to the provisional standard has been developed and many demonstrations of the picture

TABLE 2: THE PROVISIONAL NHK HDTV STANDARD

Number of scanning lines	1125
Aspect ratio	5:3
Line-interlace ratio	2:1
Field-repetition frequency	30 Hz
Video bandwidths:	
Luminance (Y) signal	20 MHz
Colour-difference (C) signals	
wideband (C_W)	7 MHz
narrowband (C_N)	5.5 MHz

quality obtainable from the system have been given during the past year or two. Some of the picture material recorded and demonstrated has been prepared by CBS. The general reaction to these demonstrations has been very positive - it being generally agreed that the provisional standard does provide 'true HDTV' with picture quality comparable with that obtained from current 35 mm film.

However, in the context of a proposal for a worldwide HDTV standard there are two major problems with the NHK proposals as they now stand. The first problem is the large r.f. bandwidth required for transmission of the wideband video signals. Several methods of coding the video signals for DBS transmission have been suggested,[10] but all would seem to require a video bandwidth of around 30 MHz and an r.f. bandwidth in excess of 100 MHz.

The second problem relates to the question of compatibility. Even if it were to become possible to compress the proposed HDTV signal into an r.f. bandwidth of (say) 50 MHz, the transmitted signal would be quite incompatible with any of the existing terrestrial standards. Although this might not be a major problem in some parts of the world, it would certainly be a major one in Europe where, under the Region 1 WARC '77 plan, each country has been allocated a maximum of five non-adjacent 27 MHz channels within a frequency plan based upon 19.08 MHz channel separation. The only feasible way ahead for Europe, it would seem, is to find a solution which 'bridges the gap' between the existing 625/50/2:1 conventional television system and the requirements outlined for an HDTV system.

ENHANCED VISION STANDARDS FOR DIRECT SATELLITE BROADCASTING

The advent of direct broadcasting by satellite (DBS) will provide broadcasting organisations with a unique opportunity to introduce compatible improvements to the existing television transmission standards.

In DBS in Europe the use of frequency modulation in broader-bandwidth r.f. channels centred in the 12 GHz band means that the broadcast satellite signals will not be directly compatible with terrestrial VHF/UHF transmissions using a.m. vestigial sideband modulation. At minimum, a new type of aerial, a new type of front end, and a new type of demodulator will be required for reception. Furthermore, there will be the need to re-modulate

the vision and sound signals onto a VHF or UHF carrier to provide an acceptable DBS input to those existing receivers which incorporate only an r.f. input.

It has been recognised that the new receiver interface required for DBS provides broadcasters with the opportunity to update and improve the transmission standards for vision and sound. Several proposals for new DBS transmission standards have already emerged during the past few years: firstly, sound/data systems employing digital modulation and capable of providing several high-quality sound channels;[11] secondly, 'enhanced' vision systems which (i) avoid or reduce the cross-effects associated with the existing band-sharing systems (PAL, SECAM, NTSC) by keeping the component signals separate in the transmitted waveform, and (ii) provide improved horizontal resolution by utilising more fully the wider transmission bandwidth available with DBS.

Of particular interest from the HDTV point of view is the proposal put forward by the IBA for a DBS modulation system known as C-MAC[12] which has features well suited to the future evolution of compatible higher definition television.

C-MAC

The C-MAC system, which has been submitted by the EBU to the CCIR as the DBS standard for Europe, transmits the component vision signals and the digital sound signals in a time-division multiplex within the (64 μs) television line. The digital sound signals are compressed into a 'burst' of 20.25 Mbit/s data of approximately 10 μs which fits into the line-blanking period. The luminance (Y) and colour-difference signals (U and V) are time-compressed to form a time-division *M*ultiplexed *A*nalogue *C*omponent signal which fits into the active line period following the digital data as shown in Fig. 3.

The colour-difference signals are transmitted on alternate lines in order to minimise the compression ratios for all signals and to improve noise performance. The resulting compression ratios for the luminance and colour-difference signals are 3:2 and 3:1 respectively. A consequence of time compression is a proportional increase in bandwidth. Thus, in a basic C-MAC system with 5.6 MHz luminance bandwidth, a video transmission bandwidth of 8.4 MHz is required following compression.

It should be noted, however, that the absence of subcarriers in the C-MAC system means that, in principle, the transmitted video bandwidth could be widened to provide increased horizontal resolution. The only limitations are those set by r.f. adjacent channel considerations, and there is evidence to suggest that the transmitted bandwidth of the luminance signal could be extended from 8.4 MHz to around 11 MHz without encountering problems.[13]

A further feature of the C-MAC system is the facility for signalling changes in the boundaries between the digital data and colour-difference signals, and between the colour-difference and
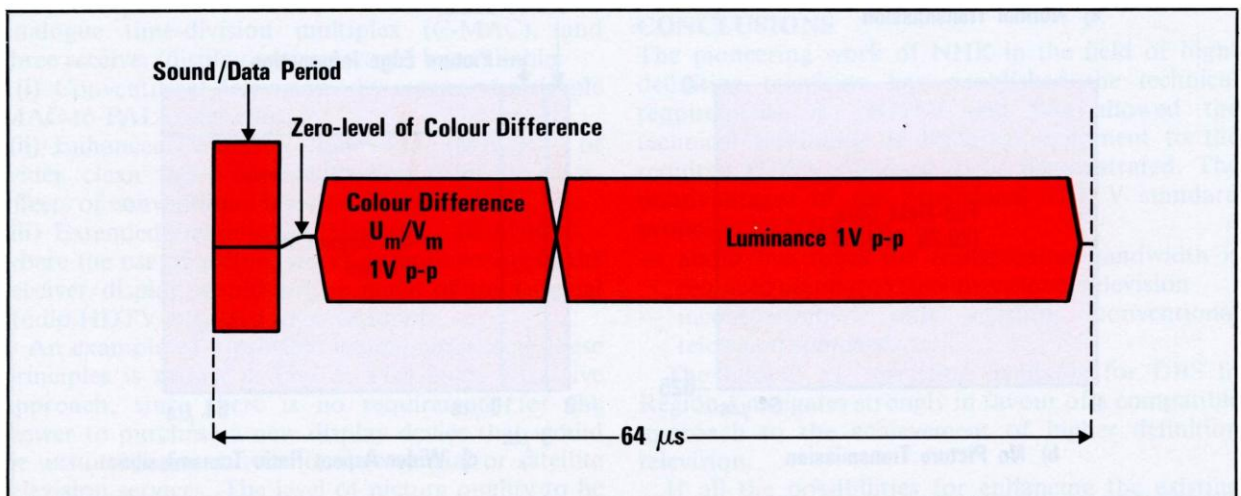

Fig. 3. A typical line of C-MAC.

luminance signals, to allow for various service options. This is illustrated in Fig. 4 which shows some examples of how the television frame can be configured. In summary the basic C-MAC system:
— provides a 'clean' luminance signal with a bandwidth of 5.6 MHz (compared to ~ 3.5 MHz in PAL)
— provides 'clean' colour-difference signals with a bandwidth (3 dB) of up to 2.8 MHz (compared to ~ 1.0 MHz in PAL)
— eliminates cross-colour and cross-luminance
— gives an overall improvement in subjective noise compared to PAL
— permits inclusion of up to eight high-quality sound channels to accompany standard MAC pictures
— meets all the technical requirements for adoption as the European transmission standard for DBS.

In addition, the system has potential for the transmission of further information necessary to provide pictures of higher definition and wider aspect ratio for viewing on large-screen displays in the home. These possibilities are explored further in Chapters 2 and 3.

THE COMPATIBLE APPROACH TO HIGHER-DEFINITION TELEVISION FOR DBS

This approach would be to take an HDTV studio standard which is related simply to the conventional standard and to code it such that the resulting transmitted signal is both compatible with conventional television and fits into a single WARC '77 r.f. channel. The received pictures would be scan-converted to a rate sufficient to overcome display defects.
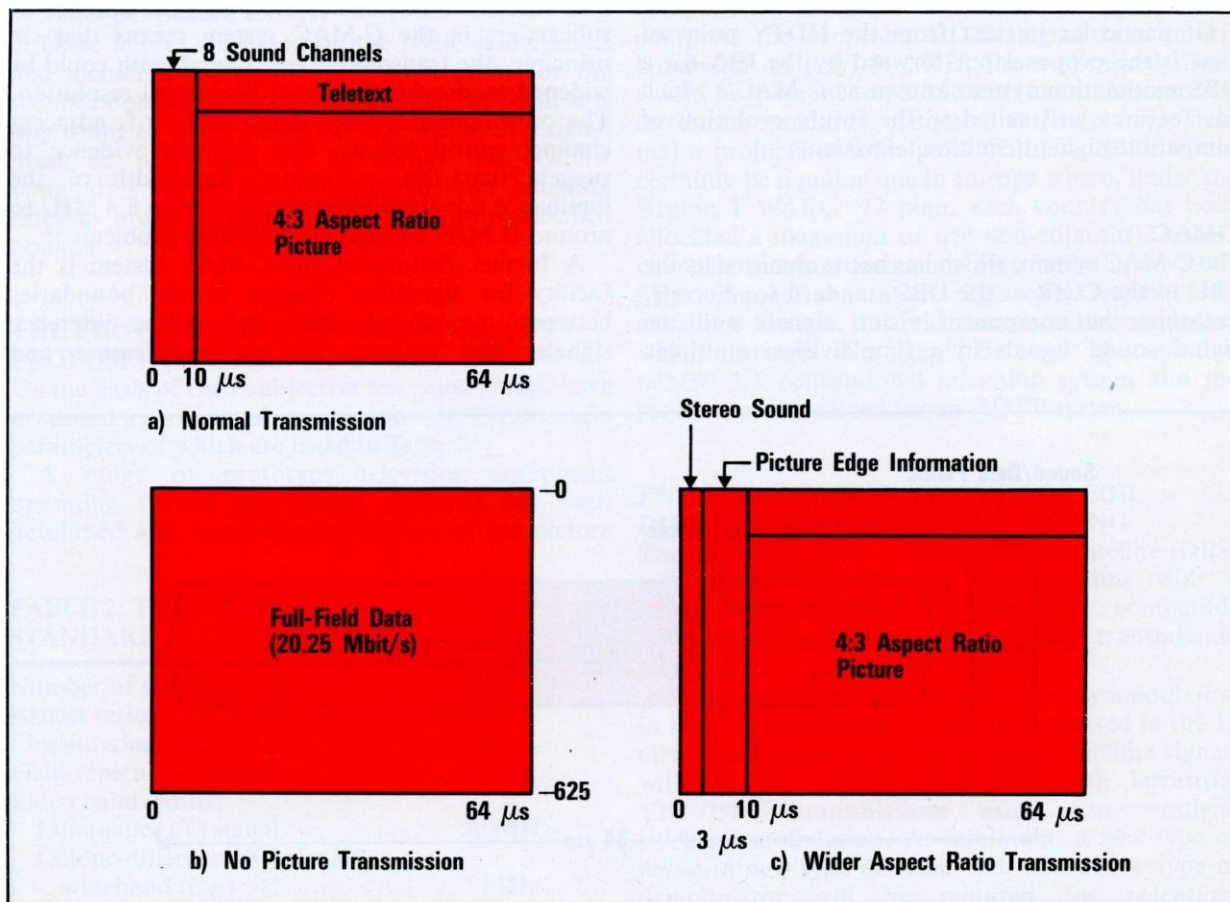
The transmission standard could be based upon

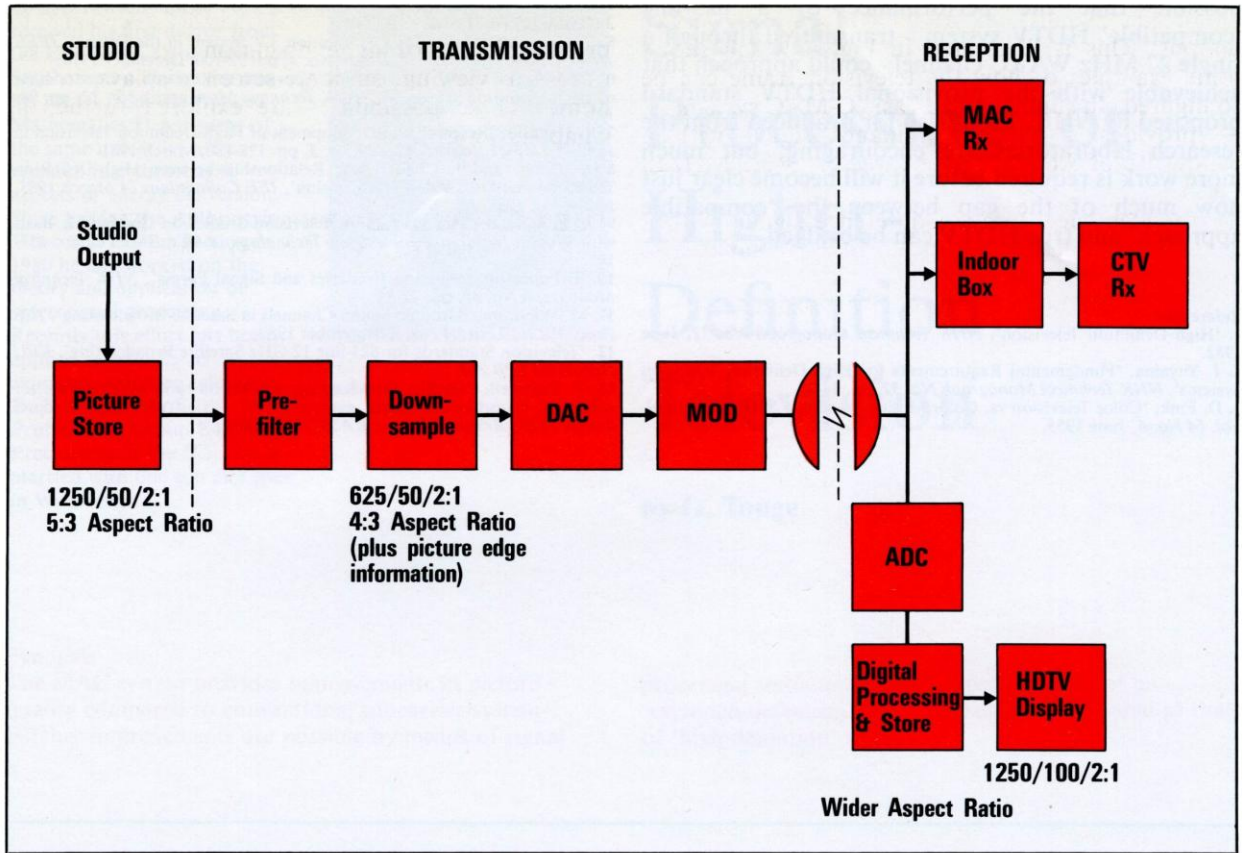**Fig. 4.** C-MAC transmission options.

Fig. 5. A compatible 'extended-definition' television system.

analogue time-division multiplex (C-MAC), and three receiver/display options would be available:

 (i) Conventional Television - by means of a simple MAC-to-PAL coder chip.

 (ii) Enhanced-Definition Television (MAC) - of wider 'clean' video bandwidth, free from the cross-effects of conventional television.

(iii) Extended-Definition Television (E-MAC) - where the use of picture stores and processing in the receiver/display would enable much of the original studio HDTV standard to be restored.

An example of a possible system embracing these principles is shown in Fig. 5. This is an attractive approach, since there is no requirement for the viewer to purchase a new display device that would be unsuitable for conventional terrestrial or satellite television services. The level of picture quality to be displayed is a receiver option decided by the viewer.

CONCLUSIONS

The pioneering work of NHK in the field of high-definition television has established the technical requirements for HDTV and has allowed the technical feasibility of building equipment to the required HDTV standard to be demonstrated. The disadvantages of the provisional HDTV standard proposed by NHK are:

— about five times the transmission bandwidth is required compared to conventional television

— incompatibility with existing conventional television standards.

The limited r.f. spectrum available for DBS in Region 1 mitigates strongly in favour of a compatible approach to the achievement of higher definition television.

If all the possibilities for enhancing the existing 625-line standard are realised in practice, it is
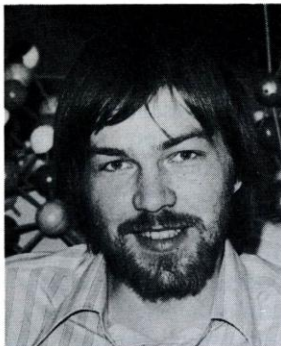
possible that the performance of a 625-line 'compatible' HDTV system - transmitted through a single 27 MHz WARC channel - could approach that achievable with the provisional HDTV standard proposed by NHK. Results so far produced from the research laboratories are encouraging, but much more work is required before it will become clear just how much of the gap between the 'compatible approach' and true HDTV can be bridged.

References
1. 'High Definition Television', *NHK Technical Monograph No. 32*, June 1982.
2. I. Yuyama, 'Fundamental Requirements for High-Definition Television Systems', *NHK Technical Monograph No. 32*, pp. 14-20.
3. D. Fink, 'Color Television vs. Color Motion Pictures', *SMPTE Journal, Vol. 64 No. 6*, June 1955.
4. D. Pearson, *Transmission and Display of Pictorial Information*, Chapter 2, Pentech Press, London 1975.
5. T. Fujio, 'A Study of High-Definition TV System in the Future', *IEEE Trans. on Broadcasting Vol. BC-24 No. 4*, pp. 92-100, December 1978.
6. T. Nishizawa and Y. Tanaka, 'New Approach to Research & Development of High Definition Television', *NHK Technical Monograph No. 32*, pp. 98-101.
7. K. Hayashi, 'Research and Development of High-Definition Television in Japan', *SMPTE Journal Vol. 90 No. 3*, pp. 178-186, March 1981.
8. G. Tonge and I. Childs, 'The Relationship between High-Definition Television and DBS Video Transmission', *IEE Colloquium 14 March 1983, Digest No. 1983/22*.
9. B. Wendland, 'High Definition Television Studies on Compatible Basis with Present Standards', *Television Technology in 80's*, SMPTE, pp. 151-165.
10. T. Fujio, 'Transmission Primaries and Signal Forms', *NHK Technical Monograph No. 32*, pp. 27-34.
11. M. Windram, 'Multiple Sound Channels in Satellite Broadcasting', *IEE Proc. Vol. 129 Part A No. 7*, September 1982.
12. 'Television Standards for 625-line 12 GHz Satellite Broadcasting', *EBU Document SPB 284*.
13. P. Shelswell, 'Satellite Broadcasting: protection ratio requirements for enhanced transmissions using extended PAL vision and digital sound design', *BBC Research Report RA207*, May 1982.

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Signal Processing for Higher-Definition Television

by G. Tonge

Synopsis

The MAC system provides improvements in picture quality compared to conventional subcarrier systems. Further improvements are possible by means of signal processing techniques, and the performance of an 'extended-definition' MAC approach is compared to that of 'high-definition' systems.

INTRODUCTION

Recent demonstrations of high-quality large-screen television pictures based on an 1125-line standard proposed by NHK of Japan have provoked an increased interest in higher-definition television. In particular, some rather fundamental questions have been asked with regard to the bandwidth needed to broadcast such signals, and issues raised of compatibility with existing broadcast television standards. Many observers have considered that the bandwidth required for transmission of such signals is excessive for broadcasting by either terrestrial or satellite networks. Similarly, in a broadcast environment, compatibility with existing standards is of primary significance.

There are the following four factors which are important to higher-definition television, and which should be considered when comparing the capabilities of a compatible system with those of 'true' HDTV:

Large Screen

A larger display, provided that it is bright enough and has sufficient colour fidelity, itself causes an increased visual impact on the observer. Without doubt, the high-quality large-screen projection displays developed by NHK and by Japanese industry have played a significant role in the success of demonstrations of the 1125-line system.

Wider Aspect Ratio

The consensus view developed from several subjective tests has been that, as the display size increases, so a wider aspect ratio becomes more favourable for most (but not all) types of picture content. Because of this effect, the NHK 1125-line system has a 5:3 aspect ratio in preference to the ratio of 4:3 currently employed in broadcast television. Indeed, in the cinema industry an even wider aspect ratio is now common. Although it is generally accepted that a wider aspect ratio is favourable for

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larger screens, the relative importance of screen size and aspect ratio is difficult to assess. For example, an increase in display area from 0.2 m² (a 26″ television set) to 1 m² will represent a certain improvement. Having achieved this, an increase in aspect ratio from 4:3 to 5:3 will cause a further improvement. The relative significance of these two improvements is unclear.

Despite this uncertainty, a wider aspect ratio might well prove to be a key 'selling point' for the would-be provider of a higher-definition television service.

Better Resolution

Resolution is clearly an important factor when considering a large-screen display. In an ideal situation the resolution provided by a high-definition television system will be as good as the resolving power of the eye (for the typical viewing distance). This gives rise to impractical requirements as discussed in the previous chapter. The NHK 1125-line system, for example, does not provide such 'perfect' high resolution. Indeed, it is likely that, when viewed on a projection display, the full resolution capabilities of the 1125 lines are not realised. It can be argued that a system using fewer lines is capable of providing sufficient quality - in purely *resolution* terms - for high-quality large-screen display. For example, systems for video-to-film transfer using 655 lines have been reported as producing good results.[1]

Lack of Spurious Effects

Conventional broadcast television tends to be plagued with what could be called 'spurious effects'. Indeed, many of these effects serve to reduce the perceived resolution on display to below the theoretical capabilities of the system. Examples of such effects are:

(i) CROSS-COLOUR AND CROSS-LUMINANCE. These arise as a result of band-sharing in the composite colour coding system.

(ii) INTERLINE FLICKER. This is an effect visible on fine vertical frequency detail and vertical edges. It occurs when, because of the use of interlace on the display, parts of the picture flicker at the frame rate (i.e., 25 Hz in Europe, 30 Hz in the USA).

(iii) LARGE-AREA FLICKER. This occurs at the field rate and is much more visible with 625-line systems (50 Hz) than it is with 525-line systems (60 Hz). It is again a display effect.

(iv) VISIBILITY OF THE LINE STRUCTURE. With an interlaced display this tends to be dominated by line

crawl, where a single field raster (i.e., half the full number of lines) is seen to move vertically.

(v) LINE ALIASING. This is a source effect in which a highly detailed area in the scene is aliased by the scanning line structure to give a spurious lower frequency pattern. With interlace this is more evident with vertical scene movement.

The main improvement provided by the NHK 1125-line system in this regard is that the signal is coded from source to display in separate components, rather than in a band-sharing composite format. Thus, cross-colour and cross-luminance are non-existent. Each of the other effects is still present, although interline flicker, line visibility and line aliasing are reduced because of the higher number of lines.

A COMPATIBLE SCHEME FOR DIRECT BROADCASTING BY SATELLITE

The fact that in Europe only five channels have been allocated to each country for DBS has several implications when considering the broadcasting of higher-definition television. In the United Kingdom, for example, it would be very difficult to envisage a higher-definition television service which occupies more than one of the allocated channels. This is especially true at the onset of such a service. 'Ideally, therefore, from a broadcaster's point of view, a higher-definition television service should occupy only one channel and should essentially be a *receiver option*.

This means that the same transmitted signal could be received by both a 'conventional' DBS receiver for small-screen display and by a 'higher-definition' receiver for large-screen display.

At first view, these requirements appear to be unrealistic. However, recent developments in Europe have made these goals much more attainable. A new coding scheme C-MAC (Multiplexed Analogue Components) has emerged as the DBS standard in the UK and has been recommended by the EBU as a European standard. The adoption of C-MAC opens the door to picture-quality enhancement by means of signal processing.

With C-MAC used as the coding scheme for DBS, one could envisage an approach to higher-definition television as outlined in Fig. 1. This approach satisfies the requirements that only one DBS channel is occupied and also that higher definition is a receiver option. A high-quality, separate-component, 625-line 50 Hz 2:1 interlaced source is first MAC-
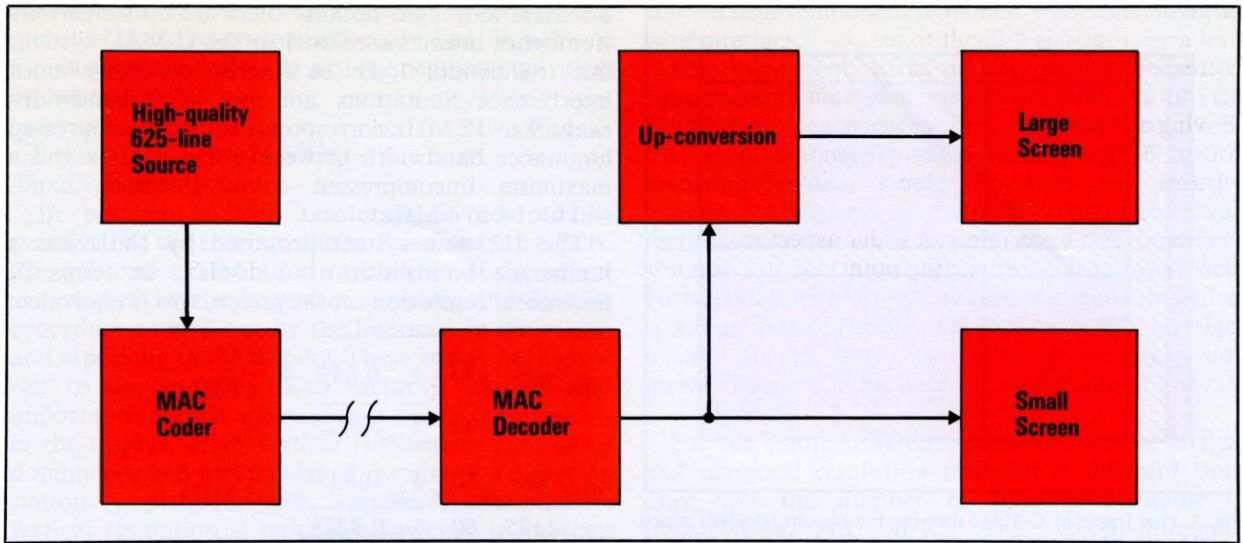
Fig. 1. A compatible approach to higher-definition television.

coded. This source may be derived via the preprocessing of a higher line-rate source. After transmission via the DBS channel, the signal is MAC-decoded and then up-converted for large-screen display. Alternatively, the signal can simply be MAC-decoded and then displayed on a conventional small-screen display. Some features of this approach will now be considered in more detail.

Aspect Ratio

A closer look at the flexible format of the C-MAC coding scheme reveals the possibility of a compatible wider aspect ratio service. Figure 2 illustrates, over one frame, the proportion of transmission time which is actually used for active picture information. The blocks labelled C and Y represent the colour-difference and luminance signals respectively, and together they occupy 53 out of 64 µs in width and 575 out of 625 lines in height of the frame. The remaining width (line-time) is occupied by digital data, while 48 out of the remaining 50 lines are spare, so far as transmission is concerned. One line per frame (625) is dedicated as a digital control line which conveys information concerning the data/vision and vision/vision boundaries within that frame. A second line (624) is earmarked to convey a carrier-recovery signal. If the number of high-quality sound channels which can be supported is reduced from eight to two (for single-language stereo) then the data period can be reduced in length and the regions shaded in Fig. 3

become available for the coding of wider picture information. Assuming the same 'picture density' as that obtained in the 4:3 aspect ratio region (comprising the areas labelled C and Y in Figs. 2 and 3) an aspect ratio up to 4.9:3 could be supported by incorporating the shaded regions. If more practical allowances are made for transition times between
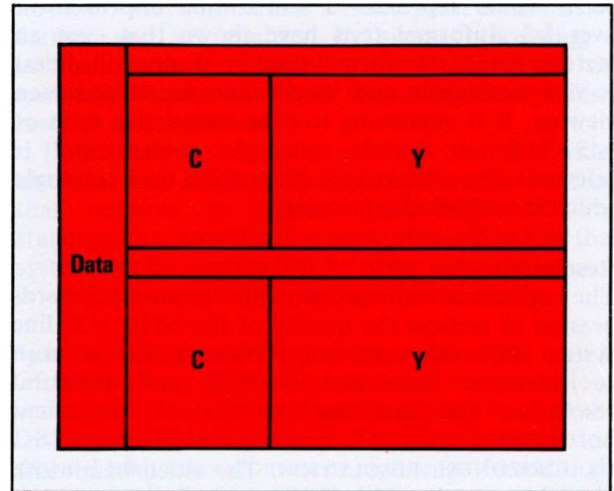

Fig. 2. One frame of C-MAC illustrating the proportions of time occupied by the colour-difference (C) and luminance (Y) vision components for a 4:3 aspect ratio.
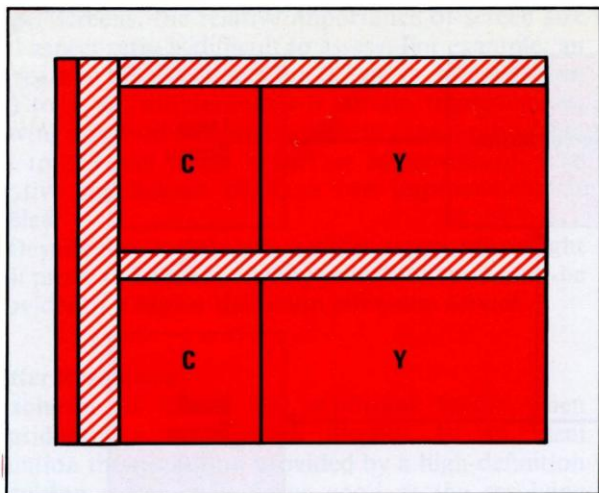
Fig. 3. One frame of C-MAC showing the regions (shaded) which could be available for wider aspect ratio information.

picture 'block' boundaries, an aspect ratio of 4.7:3 is certainly possible, as described in Chapter 3.

This potential increase in aspect ratio would not affect bandwidth requirements in the transmission channel, although source and display bandwidths would be proportionately increased. The use of the field-blanking period in transmission, as envisaged here, would necessitate the incorporation of addressable field storage in the higher-definition receiver as well as in the MAC coder.

It is likely that an increase in aspect ratio to around 4.7:3 would represent a worthwhile improvement over 4:3. Informal tests have shown that even an increase to 3:2 (the format used in 35 mm still slides) is very noticeable and worthwhile for large-screen viewing. It is interesting to note here that a ratio of $(\sqrt{5}+1):2$ (i.e., 4.85:3), called the 'golden ratio', is referred to by artists as the proportion for a rectangle which is aesthetically pleasing.

Resolution

The key area in which a compatible approach is hard-pressed to achieve the quality of the NHK 1125-line system is that of resolution. Here resolution is taken to refer to horizontal, vertical and temporal resolution (incorporating aspects of movement portrayal).

(i) HORIZONTAL RESOLUTION. The video bandwidth available in the FM DBS channel of 27 MHz bandwidth is probably somewhere between 9 and 12 MHz. Current tests have used a video bandwidth of

8.5 MHz although, because there are no subcarriers (for either sound or colour) in the C-MAC system, this bandwidth can be increased freely until interference limitations are met. The bandwidth range 9 to 12 MHz corresponds to an uncompressed luminance bandwidth between 6 and 8 MHz and a maximum uncompressed colour-difference bandwidth of 3 to 4 MHz.

The 1125-line system proposed by NHK has a luminance bandwidth of 20 MHz. In terms of horizontal resolution on the screen, this is equivalent to:

$$20 \times \frac{625}{1125} \times \frac{50}{60} \times \frac{4}{5} \times \frac{0.835}{0.8125} = 7.6 \text{ MHz}$$

$$20 \times \frac{525}{1125} \times \frac{60}{60} \times \frac{4}{5} \times \frac{0.835}{0.8285} = 7.5 \text{ MHz}$$

for 625-line and for 525-line systems respectively. The above calculations incorporate the ratio of lines, field rates, aspect ratios and normalised active line times (in that order) for the respective systems. The colour-difference bandwidth (at source) in the NHK system is in a similar way equivalent to 2.7 MHz and 2.1 MHz (for 625 lines) for the wideband and narrowband colour-difference axes respectively. For transmission purposes, it has been proposed that these colour-difference bandwidths be reduced to the equivalent of 1.9 MHz and 1.5 MHz respectively (in conjunction with alternate-line coding).

When considered in these equivalent terms, therefore, the horizontal resolution capabilities of the NHK 1125-line system do not seem to be beyond the reach of a single-channel compatible system for DBS.

(ii) VERTICAL RESOLUTION. The influence of the *transmission* line standard and that of the *display* line standard need to be considered separately. The theoretical vertical resolution limit is set by the line format conveyed in the transmission, and can be defined as half of the vertical sampling frequency. If we assume a 625-line transmission format for the luminance (having 575 active lines) then the upper limit for vertical frequency in the system is:

575/2 = 287.5 cycles per picture height (c/ph).

In terms of equivalent horizontal frequency this is:

$$287.5 \times \frac{4}{3} \times \frac{15625}{0.8125} = 7.37 \text{ MHz}$$

where 4/3 is the aspect ratio, 15625 is the line rate and 0.8125 is the normalised active line time. For a 525-line system (with 485 active lines), an equivalent calculation yields:

$$\frac{485}{2} \times \frac{4}{3} \times \frac{15734}{0.8285} = 6.14 \text{ MHz}$$

In practice such a resolution is not usually perceived at the receiver due to line-structure effects. The full optical resolution capabilities of the source are masked by the imperfect sampling and filtering procedure carried out by the line-scan in the source and especially in the display. These effects have given rise to the so-called 'Kell factor'.[2] Of particular importance are the effects due to interlaced scanning in the display. High vertical frequencies tend to be dominated, and hence masked, by interline flicker on stationary pictures; and, therefore, the effective vertical resolution is reduced. However, if interlace effects are eliminated by up-conversion prior to display, then the theoretical limits calculated above can be approached more closely. Hence, a different *display* standard can enable the potential of the *transmission* standard to be realised more fully. Therefore, although the *capabilities* of the 1125-line system are clearly beyond those of 625- or 525-line systems, the use of signal processing for display could significantly reduce the apparent gap between the approaches. Indeed, NHK are also considering an HDTV approach which relies on display up-conversion. They calculate that, with about 800 lines, such an approach could offer vertical resolution equal to that of the 1125-line system.[3]

When one considers that in the case of a 625-line system there is an ideal capability for a vertical resolution equivalent to 7.4 MHz (while in terms of horizontal resolution 7.6 MHz has been set as a target), it appears that adequately processed pictures on this standard should be suitable for high-quality large-screen display. With 525 lines the limit is equivalent to 6.1 MHz. This is probably satisfactory and would certainly represent a significant improvement over results currently obtained with interlaced displays.[4]

(iii) TEMPORAL RESOLUTION. This is traded with vertical resolution, depending on the line format. For interlaced transmission, a vertical-temporal 'bandwidth' as illustrated in Fig. 4 could be conveyed. This bandwidth shape is purely notional since there is typically no precise filtering applied to bandlimit the signal in this way. Nevertheless, the region shaded in Fig. 4 gives a useful impression of the vertical-temporal frequency trade-offs involved with interlace.

For movement with a low vertical-frequency component (as is typical with horizontal motion) the full field-rate temporal resolution of 25 Hz (or 30 Hz for 525/60 systems) is available. For vertical motion involving vertical detail, however, the effective temporal resolution is reduced. This effect with vertical movement is a feature of all interlaced systems and is a drawback with such an approach. Fortunately, with typical picture material, this effect is rarely objectionable. On balance, 2:1 interlace seems to be the best option for television transmission with this order of magnitude of line rate and field rate.

For the colour-difference components, the vertical and temporal resolution trade-off is different since only half the number of lines is available in transmission. In MAC, the colour-difference components (U and V in Europe) are configured in an alternate-line frame-reset format, as illustrated in Fig. 5. There are sound reasons why this sequence has been preferred to the alternative four-field sequence which is not reset each frame, the main reason being that residual alias components in the frame-reset approach are much less disturbing to the eye. An implication of using this sequence, however, is that the vertical colour-difference resolution is limited to a quarter of the luminance vertical resolution capability. This is because, effectively, there are only a quarter as many vertical samples. An alternative approach is currently being considered, however, which maintains a frame-reset transmission format and yet enables, by signal processing, a vertical resolution capability of *half* that of the luminance to be conveyed to the higher-definition receiver (see Appendix 1).

In summary, therefore, although the bandwidth available in a single DBS channel is much less than that required to transmit the NHK 1125-line standard, it seems that the resolution offered by that system can be approached by using signal processing in conjunction with the existing line standards.

Spurious Effects and Display Up-conversion
Of the spurious effects discussed earlier, cross-colour and cross-luminance need not be present at all in the DBS system shown in Fig. 1. The MAC transmission channel maintains separate components. In addition, sources and displays can be interfaced simply in separate components. There is also a trend towards the use of components in other studio equipment
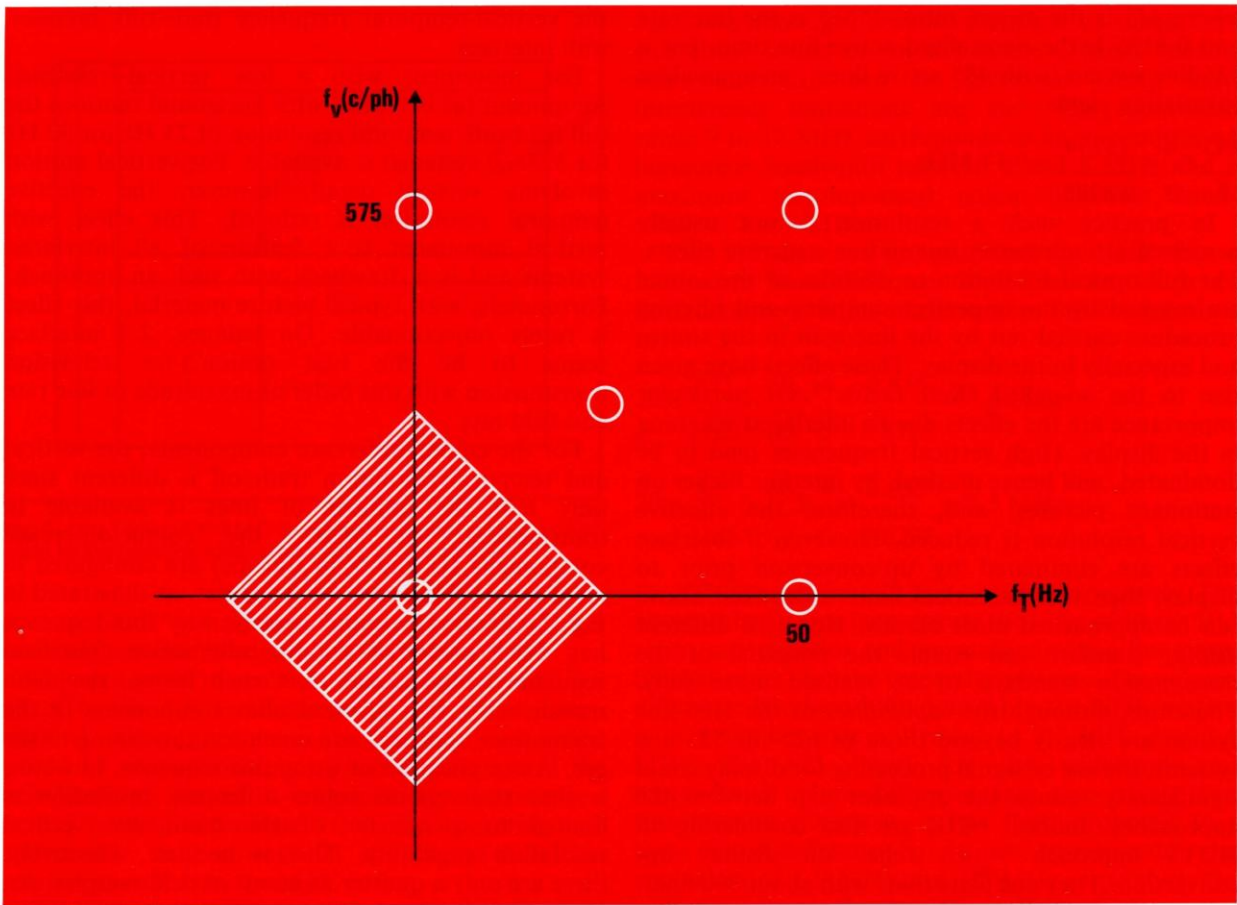
Fig. 4. Some of the repeat spectra (illustrated by circles) generated by interlaced scanning in a 625-line 50 Hz system in vertical frequency (f_v) and temporal frequency (f_T). The shaded region represents a typical 'bandwidth region'.
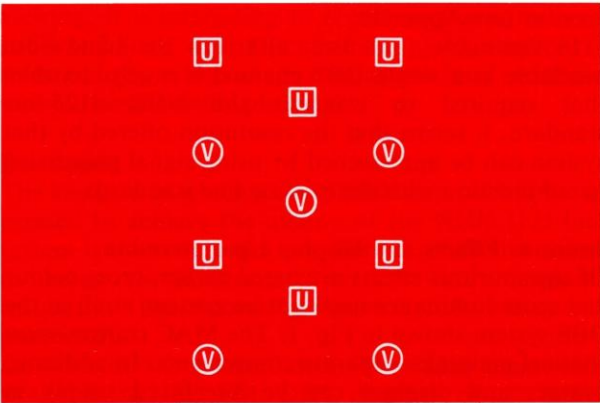

Fig. 5. Seven lines and three fields of an alternate-line frame-reset sequence for U and V colour-difference components.

such as VTRs, for which both analogue and digital component formats are being considered. The only situations, therefore, where some cross-effects can be expected are where archive material (recorded in composite form) is being transmitted.

(i) DISPLAY UP-CONVERSION. Flicker and line visibility are *display* phenomena. They can be reduced by interpolating extra lines or fields for display purposes (display up-conversion). A scheme currently under investigation at the UKIBA is illustrated in Fig. 6. Initially, a doubling of the line rate to give a 625/50/1:1 standard (i.e., sequential scan) is performed. This involves adaptive processing, as will be discussed later. A second up-conversion is envisaged which would increase the line rate by a further factor of two to give a 1250/100/2:1 display format. The first up-conversion procedure is designed to eliminate interline flicker and already
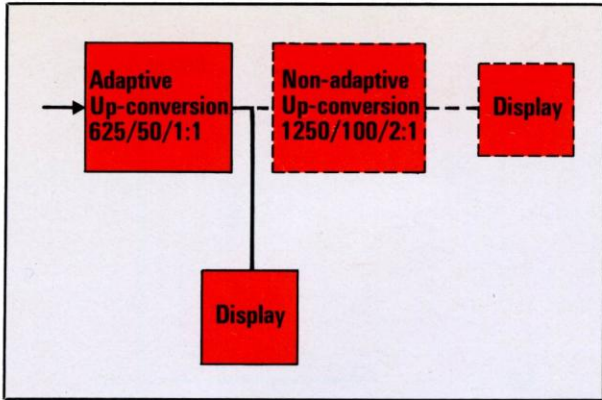
Fig. 6. Display up-conversion in two stages.

exists in hardware. The second up-conversion procedure would be used to increase the frequency of large-area flicker from 50 Hz (which tends to be perceptible, especially with bright displays and peripheral vision) to 100 Hz (which is imperceptible) and would reduce the visibility of the line structure. This equipment has not yet been built, although only straightforward non-adaptive processing is required. Both stages in the up-conversion procedure (which may be combined in a final system) involve a 1:2 interpolation (i.e., the lower standard can be derived from the higher one simply by omitting alternate lines or fields). In general, this simplifies interpolation requirements (see Appendix 2).

The first up-conversion procedure will now be described in more detail. Figure 7 illustrates a vertical-temporal grid of lines. The crosses refer to transmitted interlace lines and the circles refer to the additional lines which need to be interpolated to provide a sequential scan. The solid circle is taken as an example line to be interpolated, and the surrounding transmitted interlace lines are labelled A, B, C and D. Two simple examples illustrate the desirability of making the interpolation adaptive. If the appropriate area of the scene is stationary, then the best interpolation for the 'missing line' is to take values from the same vertical position. For example, an average of A and B would be suitable ('temporal interpolation'). This would then eliminate interline flicker and, ideally, it would enable the full vertical resolution of the 625 (or 525) lines to be resolved. If there is movement, however, then values from positions A and B would, in general, provide an erroneous interpolation; and a better option would be to use lines from the same field, for example, by

taking an average of C and D ('vertical interpolation'). In terms of frequency, the first condition (that of removing interline flicker on stationary pictures) requires a null in the post-filter response at 25 Hz. [Here the procedure of interpolating the extra lines has been combined with that of providing the existing lines unchanged to constitute a 'post-filter' interfacing the interlace and sequential scanning standards.] The second condition (that of satisfactory movement portrayal) requires that the post-filter shall have a good temporal frequency response, ideally flat to 25 Hz. The only practical way of meeting these two conflicting requirements is to have adaptive interpolation.

(ii) ADAPTIVE CONTROL. Having appreciated that a different type of interpolation is required for different local picture conditions, the generation of a control signal indicating these conditions needs to be considered. A straightforward approach would be to use a frame-difference signal, i.e.:

$$k = |A-B|$$

where k is the control signal used to determine the type of interpolation to be used on a sample-by-sample basis. In broad terms, a large frame-difference signal indicates movement, and a zero frame difference indicates stationary areas. There are certain types of movement, however, for which the frame-difference signal is zero. Consider a horizontally moving bar, for example, as illustrated
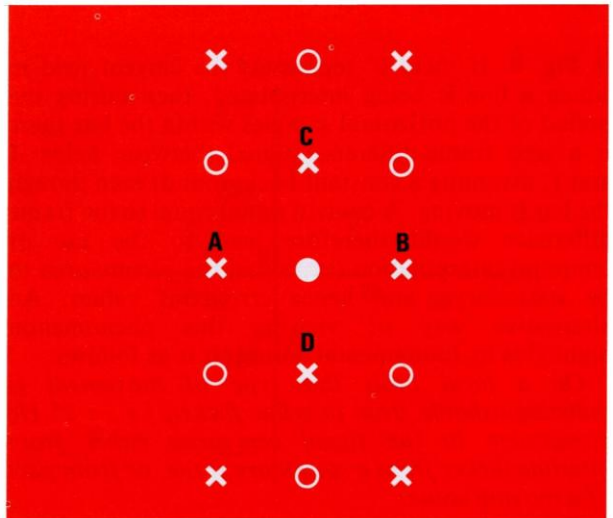

Fig. 7. Vertical-temporal grid showing five lines and three fields for sequential scan up-conversion.
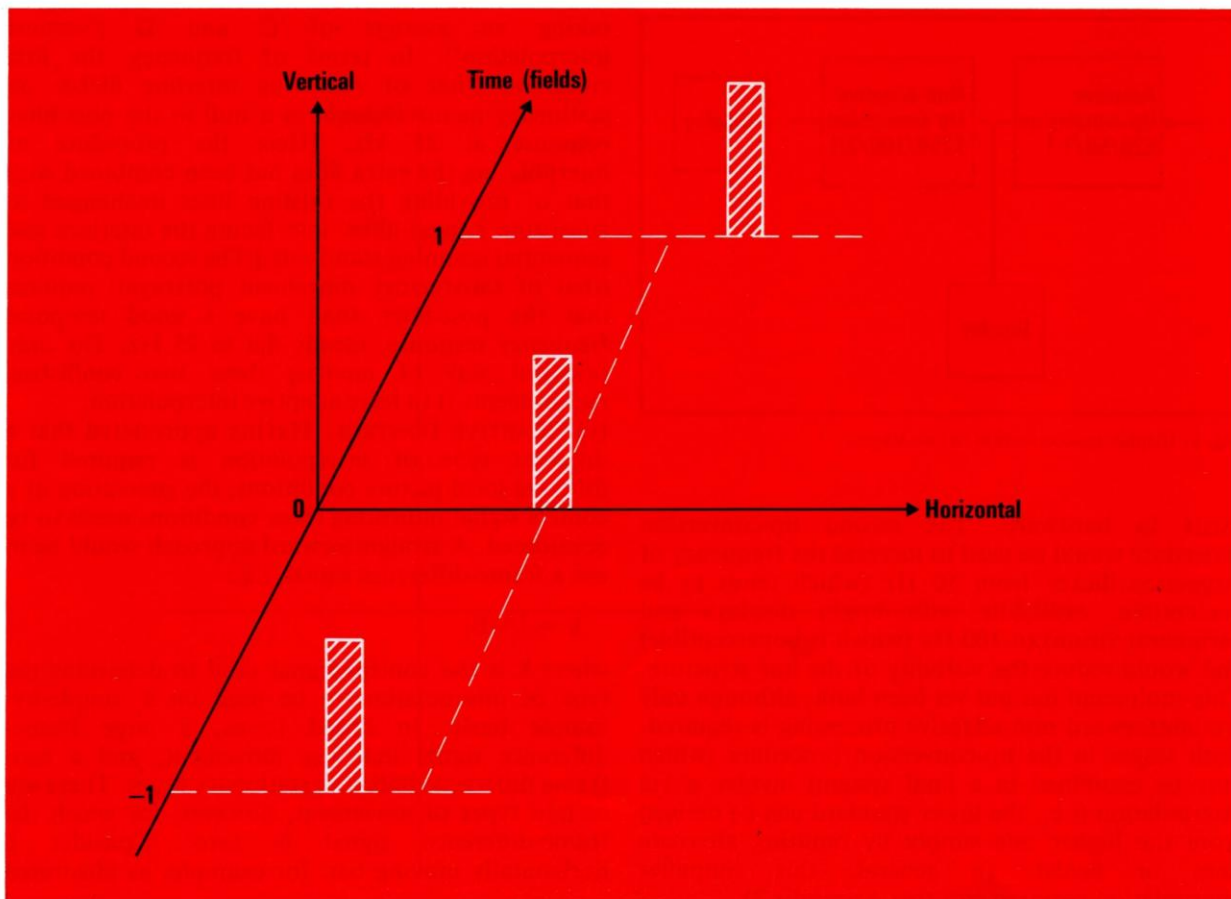
Fig. 8. A horizontally moving bar over three television fields.

in Fig. 8. If 'field 0' represents the current field in which a line is being interpolated, then during the period of the horizontal samples within the bar there is a zero frame-difference signal (between fields -1 and 1, assuming a constant background) even though the bar is moving. A control signal equal to the frame difference would therefore lead to the use of temporal interpolation (expecting the picture area to be stationary), and hence erroneous values. An alternative way of viewing this phenomenon highlights its fundamental nature. It is as follows:

On a local basis this type of movement is indistinguishable from interline flicker, i.e., a 25 Hz component in the signal can arise either from interline flicker from a stationary scene, or from part of a moving scene.

This type of confusion is fundamental in a sampled-time system. In visual psychophysics it is known as the 'correspondence problem' and has been under investigation since the 1920s.[5] Here it can be interpreted as confusion in the frequency domain (aliasing) resulting from interlace transmission. This is illustrated in Fig. 9 for a 625/50 system. A temporal frequency (f_T) of 25 Hz (marked with a star) could be a genuine temporal component arising from movement (indicated by the horizontal arrow) or it could be a vertical frequency (f_v) of 288 c/ph aliased to this position (indicated by the vertical arrows). The aliasing arises because of the repeat spectrum due to interlace centred at ± 288 c/ph and ± 25 Hz (marked by circles). In practice, however, the eye can differentiate between the two causes of the same effect by taking into account the context of the scene. For example, in one case the 25 Hz component can arise from fine detail in a stationary piece of clothing; and, in the other case, it can arise
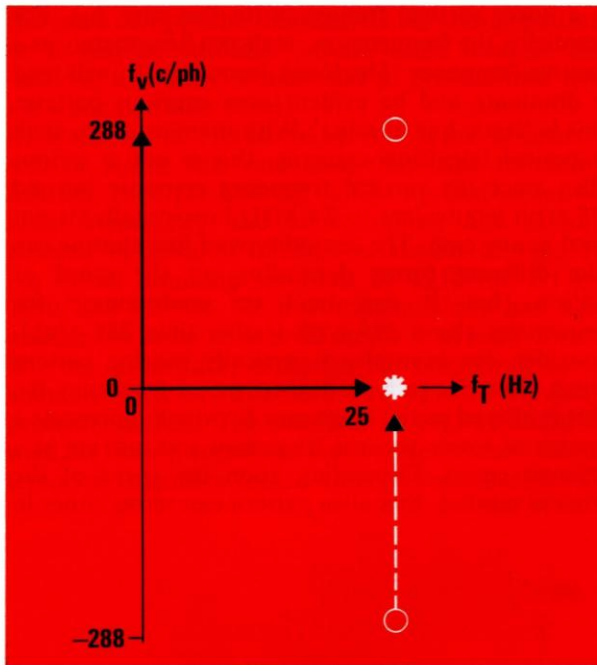
Fig. 9. Aliasing in interlace transmission. An example showing the dual interpretation of a frequency of 25 Hz.

This 'stable' central zero value tends to make this approach less sensitive to noise than the frame-difference-only approach and in many cases is the more favourable route to follow. However, the same fundamental alias difficulties described above remain.

Current work on adaptive 1:2 up-conversion for sequential display, both at the UKIBA and elsewhere,[4,6] is showing encouraging results. Such processing promises to overcome interline flicker as well as reducing, to a certain extent, line visibility (since, with a sequential display, the coarse line crawl of interlace is not evident). Further up-conversion (as shown in Fig. 6) could then be used to overcome the effects of large-area flicker and the remaining line visibility where appropriate. This procedure would not need to be adaptive since all of the 'difficult' processing would have been performed in the first up-conversion.

Preprocessing
Of the television spurious effects listed in the Introduction, the one which would still remain unaltered after display up-conversion would be line aliasing. This is a source defect which would be dealt with by source preprocessing. With an interlaced scan, line aliasing can be roughly subdivided into two types: one for stationary picture content and for motion without vertical detail, and the other for motion with vertical detail. This can be explained by considering the vertical-temporal frequency

in horizontally moving captions. This gives a clue for the control signal - it also must take into account the 'context' (i.e., the surrounding picture elements) in its indication of whether a particular picture element is part of either a moving scene or a stationary one. Some different approaches towards taking this 'context' into consideration are currently being investigated.

An alternative basis for the control signal is also under consideration. This incorporates a 'vertical difference' in addition to a frame difference such that the control signal is based on:

$$k_o = |A - B| - |C - D| \text{ (see Fig. 7)}.$$

For moving picture areas k_o tends to be positive (in which case vertical interpolation is used); for vertical detail k_o tends to be negative (in which case temporal interpolation is favoured); and, for inactive picture areas (or where vertical detail and movement are combined), k_o tends to be close to zero. In this case the interpolation which is the best 'compromise' is selected. When only the four points A, B, C and D of Fig. 10 are available, then vertical interpolation satisfies this criterion. However, if more lines are available, then a vertical-temporal filter with a flat temporal response is the best compromise option.
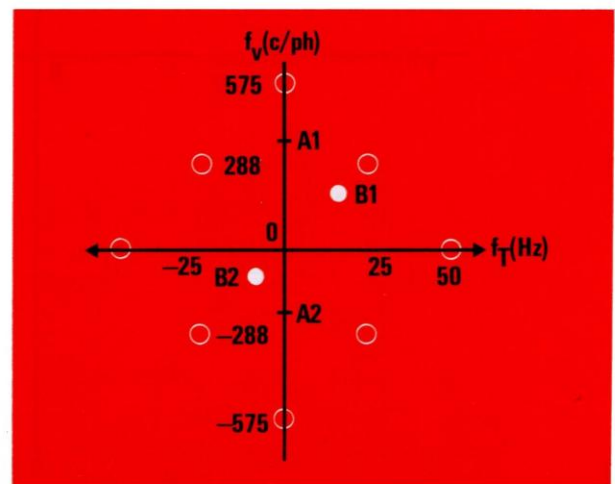

Fig. 10. Line aliasing in vertical frequency (f_v) and temporal frequency (f_T) for a 625-line 50 Hz interlace standard.
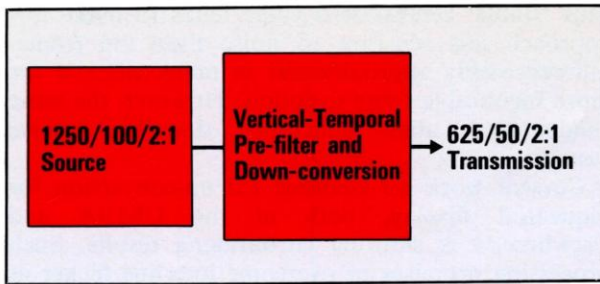
Fig. 11. A preprocessing scheme for the removal of line aliasing.

characteristics of interlace, as illustrated in Fig. 10 for a 625/50 system. The open circles represent centres of some of the repeat spectra generated by the interlace scan. A vertical frequency in the scene which is above 288 c/ph (A_1, for example) is aliased as a lower vertical frequency (in this case A_2). For simplicity, the frequency A_1 is shown here merely as a positive frequency. The lower frequency A_2 will tend to dominate and be evident as a spurious pattern. This is 'static line aliasing'. With many sources, such as typical television cameras, this is not a serious effect since the vertical frequency response beyond 288 c/ph (equivalent to 7.4 MHz horizontally) is not great in any case. The second type of line aliasing can take different forms depending on the speed of motion, but it can tend to predominate for frequencies above 144 c/ph (rather than 288 c/ph). Consider, for example, a vertically moving pattern which gives rise to a vertical-temporal frequency B_1. This is aliased as the frequency B_2 which represents a pattern of lower vertical frequency and moving at a different speed. Depending upon the speed of the original motion, this alias pattern can move either in
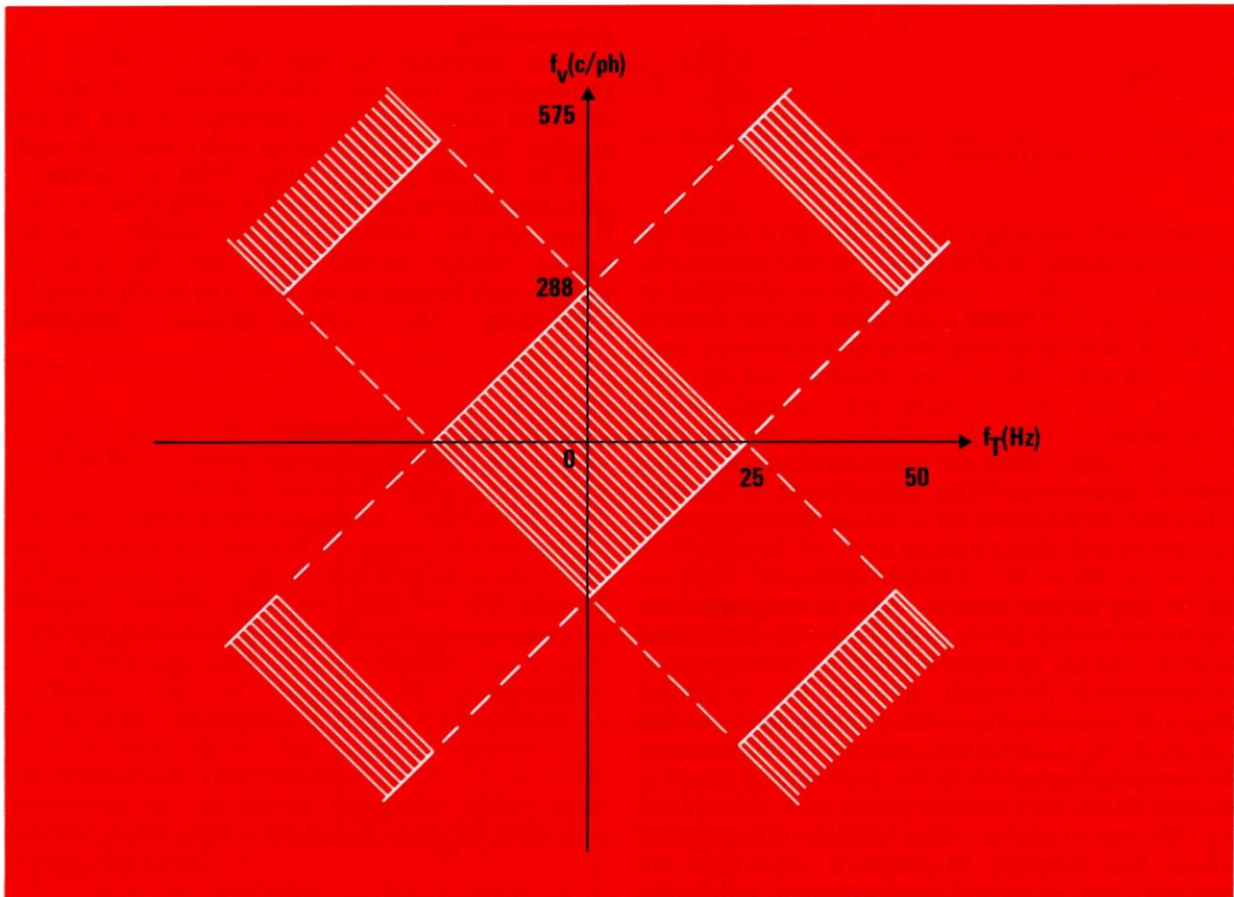

Fig. 12. Vertical-temporal pre-filtering for the removal of line aliasing.

the same or opposite direction as the source pattern, or it can be stationary. With most sources, this 'moving line alias' would tend to predominate over the static line alias effect.

(i) SOURCE PRE-FILTERING. If the scene is scanned with a higher line rate than that used for transmission, then pre-filtering can be applied to restrict alias frequencies and hence reduce line aliasing defects. A possible scheme is shown in Fig. 11. An initial scanning standard of 1250/100/2:1 (or 1050/120/2:1 for 525-line transmission) has been assumed in order to provide ample 'overhead' for the filtering procedure, although in practice a lower standard such as 1250/50/2:1 or 625/50/1:1 would probably suffice. The pre-filter in Fig. 11 could be used, in theory, to restrict frequencies to the vertical-temporal frequency region which is shaded in Fig. 12.

Down-conversion to the transmission standard would have the effect in the frequency domain of repeating those frequency regions adjacent to one another, as indicated by the dashed lines in Fig. 12. There would be no spectral overlap; and, ideally, the line alias effects discussed above could be eliminated. However, complete elimination would be obtained only by ensuring that the source camera resolution were such that there would be no response in the alias frequency regions shown shaded in the corners of Fig. 12. Otherwise, the finer structure line alias defects of the higher line-rate source would be transferred to the lower line-rate transmission. However, in any case, a 'diamond shaped' filter response as shown in Fig. 15 could not be obtained from a filter of practical complexity. Either some vertical resolution below 288 c/ph or some temporal
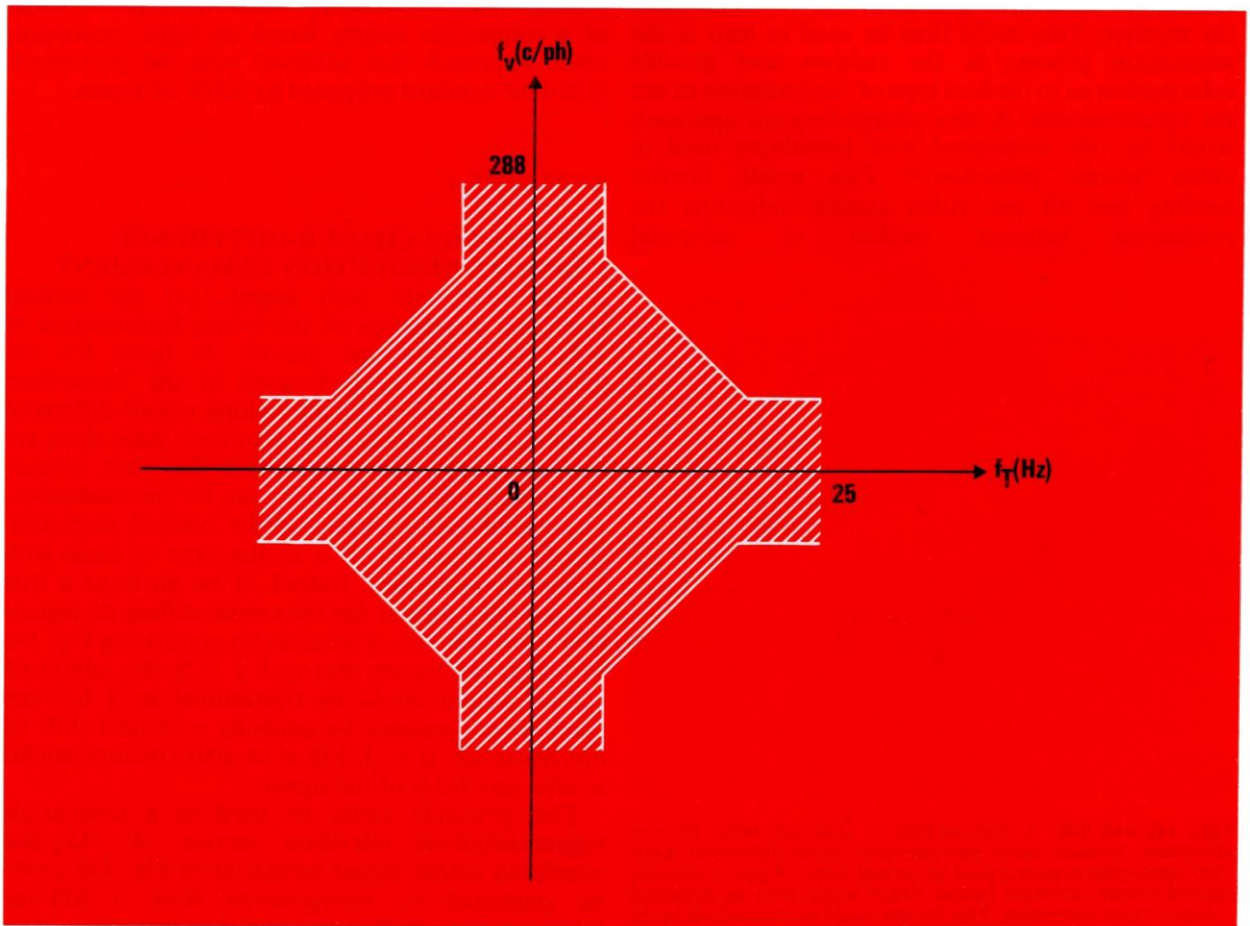

Fig. 13. An alternative restricted amount of vertical-temporal pre-filtering.

resolution below 25 Hz would need to be sacrificed in order to reduce line aliasing by a significant amount in practice. This is not necessarily desirable. A situation has previously been described (see Fig. 9) in which a certain degree of aliasing need not cause confusion. High vertical frequencies (giving rise to interline flicker) and frequencies due to movement, although 'aliased', can often be satisfactorily and usefully interpreted at the receiver. The use of a restricted amount of pre-filtering is therefore an alternative. For example, a pre-filter with a pass-band of similar shape to that illustrated in Fig. 13 would allow much of this 'useful' alias frequency region through besides restricting the moving (although not the static) line alias effect.

(ii) SOURCE SIGNALLING. An alternative approach to preprocessing is to make use of the extra information available in a higher line standard to send a small amount of control information over the channel to the receiver. This could then be used to help in the adaptation process in the receiver and provide information as to the best type of interpolation to use for up-conversion. A very straightforward approach would be one analogous with techniques used in video bit-rate reduction.[7,8] This would involve sending one bit per video sample indicating the preference between vertical or temporal

interpolation. This particular approach would be impractical in the present application, however, because of the high data rate required. At the other extreme, a very low data rate option would be to send one bit per frame to indicate whether or not that particular frame were completely stationary. In practice, a signalling format with a data rate somewhere between these two extremes might well prove worthwhile.
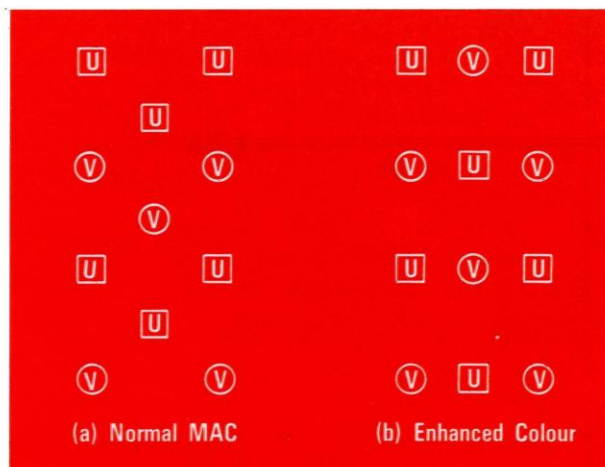
CONCLUSIONS

Some of the characteristics epitomising 'higher-definition television' have been defined and discussed. The use of signal processing based on existing line standards has been compared on the basis of these characteristics with a more direct approach using more lines on transmission. It seems possible that, for DBS applications, the performance of a compatible system based on signal processing could approach that achieved with the provisional 1125-line standard proposed by NHK of Japan.

APPENDIX 1

OPTIONS FOR COLOUR-DIFFERENCE VERTICAL RESOLUTION ENHANCEMENT

It has previously been stated that the vertical resolution capabilities of the colour transmission in MAC were only one quarter of those for the luminance. This arose because of the frame-reset sequence applied to the alternating colour-difference component lines (Fig. 14a). However, since there are half as many lines transmitted for each colour-difference component as there are for the luminance, one would expect that half the vertical resolution should be possible (for a similar type of trade with temporal resolution). Indeed, if we envisage a true 2:1 interlace format for the colour-difference signals (Fig. 14b) then this is the case. By comparing Fig. 14a with Fig. 14b we see that such a $312\frac{1}{2}$-line interlaced colour format could be transmitted in a 625-line frame-reset sequence by applying a vertical shift of one frame-line (i.e., 1/575 of an active picture height) to alternate fields of the signal.

This principle could be used in a compatible higher-definition television service. A $312\frac{1}{2}$-line interlaced colour signal format as in Fig. 14b could be generated by interpolation from a 625-line interlaced (or other) source and then transmitted in a frame-reset sequence (Fig. 14a). A conventional

Figs. 14a and 14b: A cross-section of lines and fields for two alternative formats using alternate-line colour-difference; Left: The frame-reset sequence used in normal MAC; Right: a specially derived colour-interlaced format which would offer an enhanced colour vertical resolution. This format could be transmitted in the conventional frame-reset form by applying a vertical shift of one frame-line to alternate fields of the signal.

receiver would interpret the signal as a true frame-reset sequence, while a higher-definition receiver would interpret the signal as the correct interlaced format, and process it accordingly. In this way an enhancement of vertical resolution (for stationary scenes) could be obtained for the higher-definition receiver.
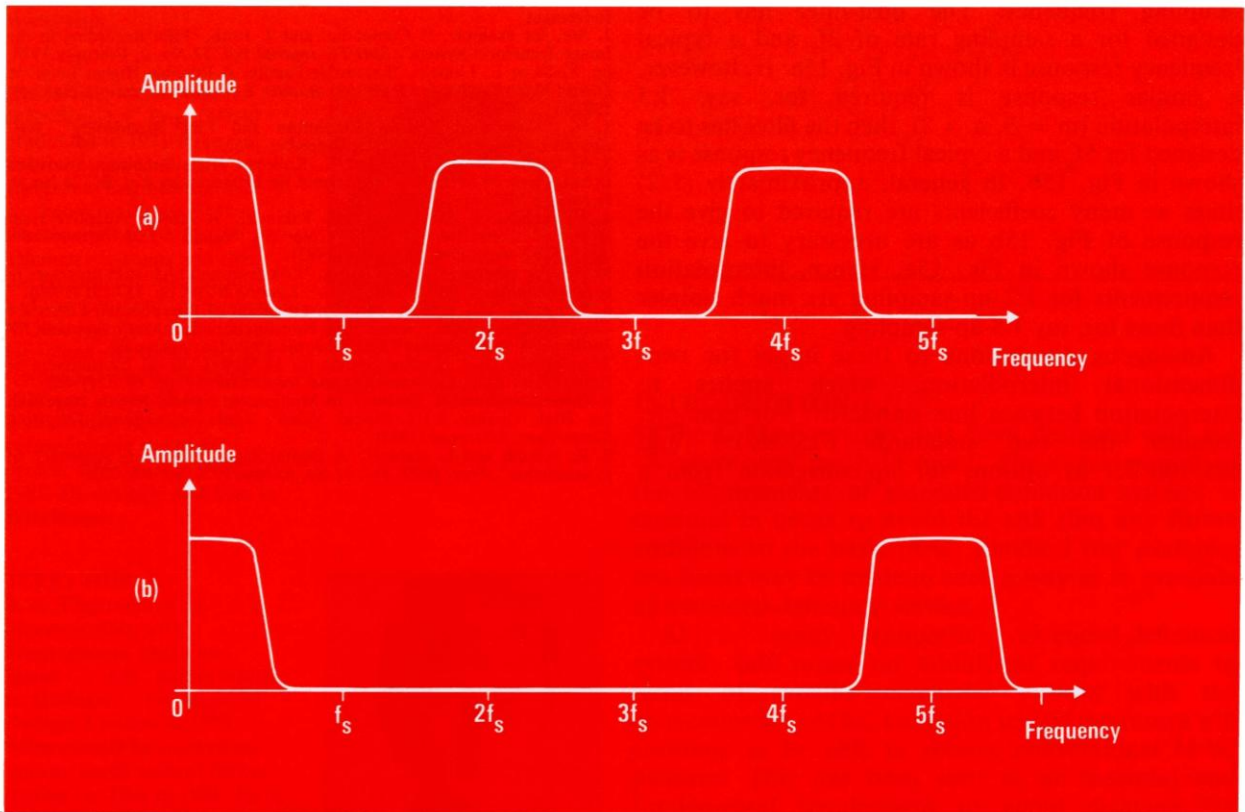
The resolution enhancement would occur at the expense of some vertical resolution on vertical movement and also at the expense of an increased amount of vertical alias in the conventional receiver. Further work is required in order to assess the significance of this alias and its implications on the extent of the enhancement which would be feasible for the higher-definition receiver.

Alternative techniques involving two-dimensional (horizontal-vertical) processing are also being considered. These might offer a more alias-free signal for the conventional receiver.
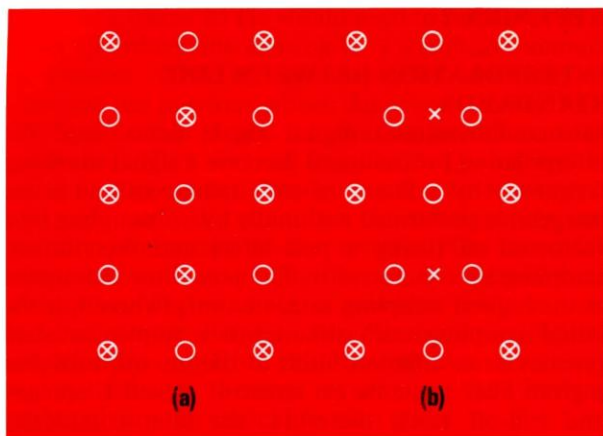
APPENDIX 2

INTERPOLATION BETWEEN LINE STANDARDS

In one-dimensional digital signal processing[9] the interpolation procedure to increase a signal sampling frequency by a factor of m/n (where m and n are integers) is performed notionally by up-sampling by a factor of m (using a post-filter) and then down-sampling by a factor of n. The post-filter is designed at the highest sampling rate, i.e., mf_s (where f_s is the initial sampling rate) although it is implemented in practice as m different filters at the $(m/n)f_s$ rate. For a given filter response (in terms of cut-off frequency and roll-off rate), therefore, the filter complexity depends on the factor m rather than (m/n). For example, consider a 1:2 up-sampling procedure (i.e., m = 2, n = 1) for which it is desired to restrict frequencies to less than $f_s/2$, where f_s is the initial

Figs. 15a and 15b: Typical one-dimensional interpolation post-filter responses: Top: for 1:2 up-sampling; Bottom: for 3:5 up-sampling.

Figs. 16a and 16b: Left: Up-conversion from a 625/50/2:1 standard to a 625/50/1:1 standard; Right: Up-conversion from a 625/50/2:1 standard to a 625/100/2:1 standard. Crosses refer to the line positions for the original standard and circles to the line positions for the up-converted standard.

625/50/2:1 standard. In terms of *line rate*, both represent a 1:2 up-conversion. However, in terms of *sampling patterns*, a 625/50/1:1 standard implies a 1:2 up-conversion while a 625/100/2:1 standard implies a 2:4 up-conversion. This is illustrated in Figs. 16a and 16b respectively. In each case, the crosses refer to the lines of the 625/50/2:1 standard, and the circles mark the lines in the appropriate up-converted standard. In the case of 625/100/2:1 (Fig. 16b) the lowest common standard is 625/100/1:1 which has *four* times the line rate of the original signal. Thus, the appropriate post-filter in this case needs to be designed on this higher frequency grid, and so has a greater complexity than one designed for 625/50/1:1 up-conversion. Other standards, such as 1250/50/2:1, would also require a 2:4 up-conversion and hence more complex interpolation. This general theoretical conclusion tends to be borne out in practice when designing even the most simple interpolation techniques for up-conversion.
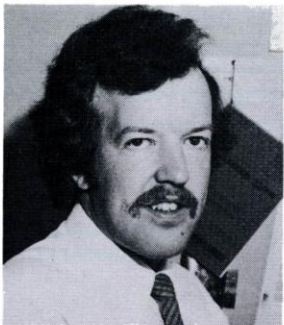
sampling frequency. The post-filter has to be designed for a sampling rate of $2f_s$ and a typical frequency response is shown in Fig. 15a. If, however, a similar response is required for, say, 3:5 interpolation (m = 5, n = 3), then the filter has to be designed for $5f_s$ and a typical frequency response is as shown in Fig. 15b. In general, approximately (5/2) times as many coefficients are required to give the response of Fig. 15b as are necessary to give the response shown in Fig. 15a. Hence, interpolation requirements for 1:2 up-sampling are much simpler than those for, say 3:5 up-sampling.

Analogous conclusions to these apply for two-dimensional interpolation, which applies to interpolation between line standards. For example, consider the two standards 625/50/1:1 and 625/100/2:1 as options for up-conversion from a

References
1. See, for example, P. Comandini and T. Roth, 'Film Recording in the Image Transform System', *SMPTE Journal Vol. 87 No. 2*, February 1978, pp. 82-84 or E. Lionetti, 'Extensible Family: A Possible Higher Level' in *Digital Video Coding for Television Studios*, EBU Demonstrations (January 1981).
2. G. Monteath, 'Vertical Resolution and Line Broadening', *BBC Engineering Monograph No. 45*, December 1962.
3. J. Ishida, T. Nishizawa and K. Kubota, 'High Definition Television Broadcasting by Satellite', *IEEE Trans. on Broadcasting Vol. BC-28 No. 4*, December 1982, pp. 165-171.
4. M. Achiha, K. Ishikura and T. Fukinuki, 'A Motion Adaptive High Definition Converter for NTSC Color TV Signals', *13th International Television Symposium, Montreux* (1983).
5. See, for example, O. J. Braddick, 'Low-level and high-level processes in apparent motion', *Phil. Trans. R. Soc. London B 290*, pp. 137-151 (1980).
6. Y. Tanaka, and T. Nishizawa, 'Investigation of Interpolation Filters for Conversion of Interlace Scanning to Non-Interlace Scanning', *Japanese TV Institute Technical Report TEBS 83-4*, pp. 19-24 (In Japanese).
7. J. Sabatier et al, 'Coding System for 34 Mbit/s Digital Transmission of Colour Television', *Commutation and Transmission 4*, pp. 69-82 (1982).
8. G. Reitmeier and R. Dischert, 'A Multiplexed Nyquist Region Approach for High Quality 2:1:1 Digital Video', *13th International Television Symposium, Montreux* (1983).
9. R. Schafer and L. Rabiner, 'A Digital Signal Processing Approach to Interpolation', *Proc. IEEE Vol. 61 No. 6*, June 1973, pp. 692-702.
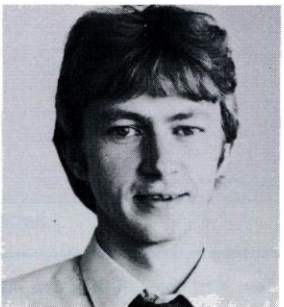
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Extended-Definition MAC

by M. D. Windram, R. Morcom and T. Hurley

Synopsis

'The advantages which may be gained by this (MAC) approach include the possibilities of extended-definition services with potential for high-quality display on screens of enhanced size.' This was stated in September 1981 in the first paper published by the Independent Broadcasting Authority describing the MAC approach to satellite broadcasting.

A specific proposal is made for an 'extended-definition' MAC service (E-MAC) in a manner totally compatible with conventional C-MAC, but exploiting the flexibility built into the C-MAC specification. The proposal provides the possibility of aspect ratios and resolution approaching those of the NHK 1125-line high-definition television system, but without the requirement for r.f. channel bandwidths unavailable in practical form to broadcasters in Europe for perhaps the next 20-30 years.

INTRODUCTION

The C-MAC system[1] has been designed with the future very much in mind. The consideration of the requirements of extended-definition systems is essential in order to avoid the risk that any future additions to the basic MAC standard (for example, test lines) may be made in such a way as to preclude an extended-definition service.

As a totally compatible extended-definition system, this poses no additional requirements in terms of satellite channels; viewers with the conventional C-MAC television sets of the future will continue to be able to receive conventional MAC pictures. This has been seen as an essential and fundamental requirement to avoid delaying the implementation and operation of MAC in its basic form.

REQUIREMENTS FOR AN EXTENDED-DEFINITION SYSTEM

For an extended-definition system to offer a useful improvement over the almost 'studio-quality' pictures of C-MAC, a number of objectives have been identified. These are:

(*a*) An increased aspect ratio - 5:3 is set as the target.

(*b*) Horizontal and vertical resolution equivalent to at least 7 MHz on a conventional display. This permits viewing of large-screen pictures at 2-3H.

(*c*) Picture processing at the receiver to remove interlace flicker and large-area flicker (see Chapter 2).

(*d*) Total compatibility with the specification for C-MAC[1] and no loss of quality with respect to conventional MAC when viewed on conventional displays.

(*e*) Capability of providing the correct part of the wide aspect ratio picture to the conventional 4:3 aspect ratio display.

(*f*) All extra complexity should be in the extended-definition display and not in the conventional display.

The system here proposed meets or approaches all these objectives to an extent which offers a useful improvement on the conventional picture, and with a quality close to that of the NHK 1125-line high-definition system.

The Options Available

The considerations for extensions to MAC fall into two main parts: increased aspect ratio and improvements in both vertical and horizontal resolution (including the use of picture processing techniques):

(i) ASPECT RATIO. In order to carry the extra information required to obtain a wider aspect ratio picture, while preserving compatibility with standard C-MAC receivers, it is necessary to examine those parts of the MAC signal which carry any redundancy.

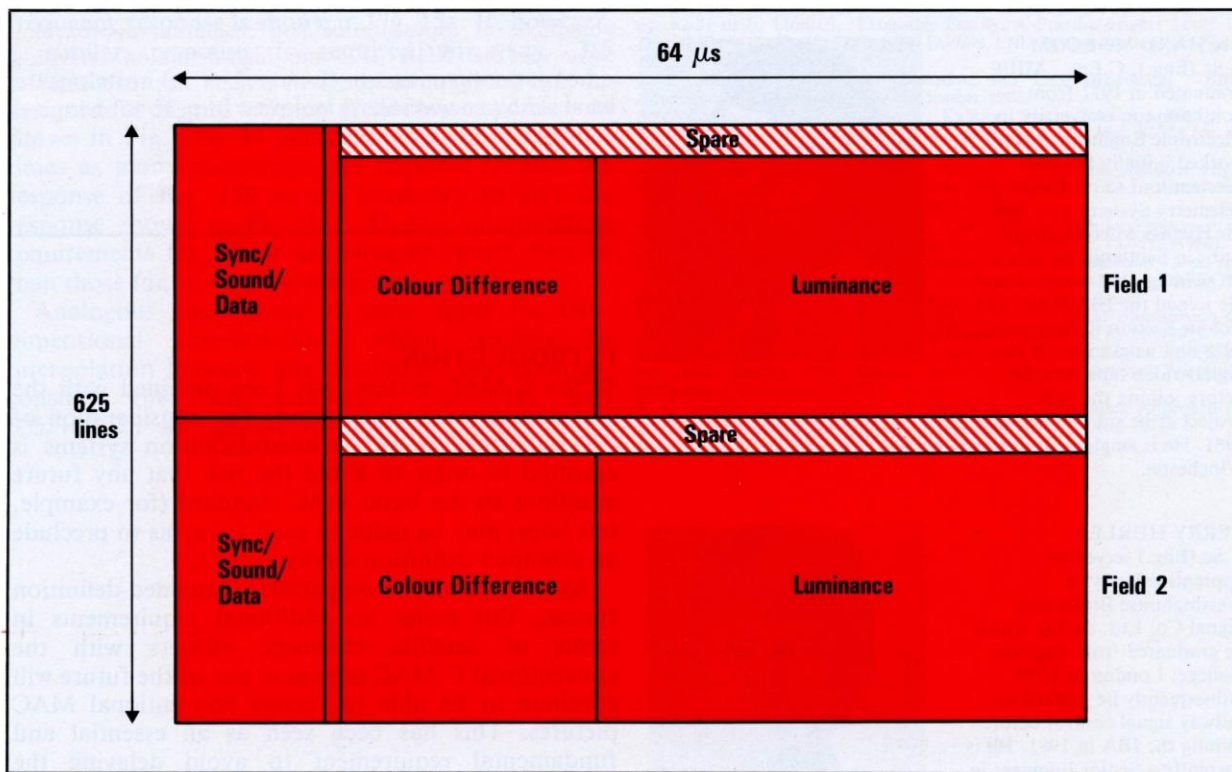If the C-MAC signal is considered over two fields in a diagrammatic form (Fig. 1), it can be seen that

Fig. 1. Transmitted frame for C-MAC.

the displayed picture leaves certain areas during the vertical-blanking intervals unused. These parts carry various signals such as 'Time-Division Multiplex Control' (line 625) and carrier recovery signals (line 624), so that perhaps of the order of 23 lines per field could be made available to convey extra information for increased aspect ratio. The potential increase in capacity is about 7% - alone this is insufficient to carry the extra 25% of information that is required by a 5:3 aspect ratio picture compared to one of 4:3 aspect ratio.

It is therefore necessary to consider a reduction in the length of the data-burst. A 203-bit burst on each line provides 8 bits of synchronisation per line and 195 bits for sound and data services. This corresponds to 162 packets per frame; and these are capable of conveying up to eight companded sound channels.

For an extended-definition service, it is reasonable to assume that a stereo sound service is essential, but that companded sound will be adequate. Two sound channels require 41 or, at most, 42 packets per frame. These packets are distributed over 624 lines with the following requirements:

41 packets = 58-bit burst including 8-bit synchronisation
42 packets = 59-bit burst including 8-bit synchronisation.

The possibility exists, therefore, to release about 7 µs per line for the purpose of conveying the extra picture information required for increased aspect ratio. Figure 2 shows the extra periods available by this method. For each line the additional capacity available for picture information is:

203 (data-burst) - 59 (sound) = 144 bits.

This compares with 1093 bits/line of the sampling rate already dedicated to picture information, an increase of approximately 13%.

A total additional capacity of 20% which could be used for picture information has therefore been
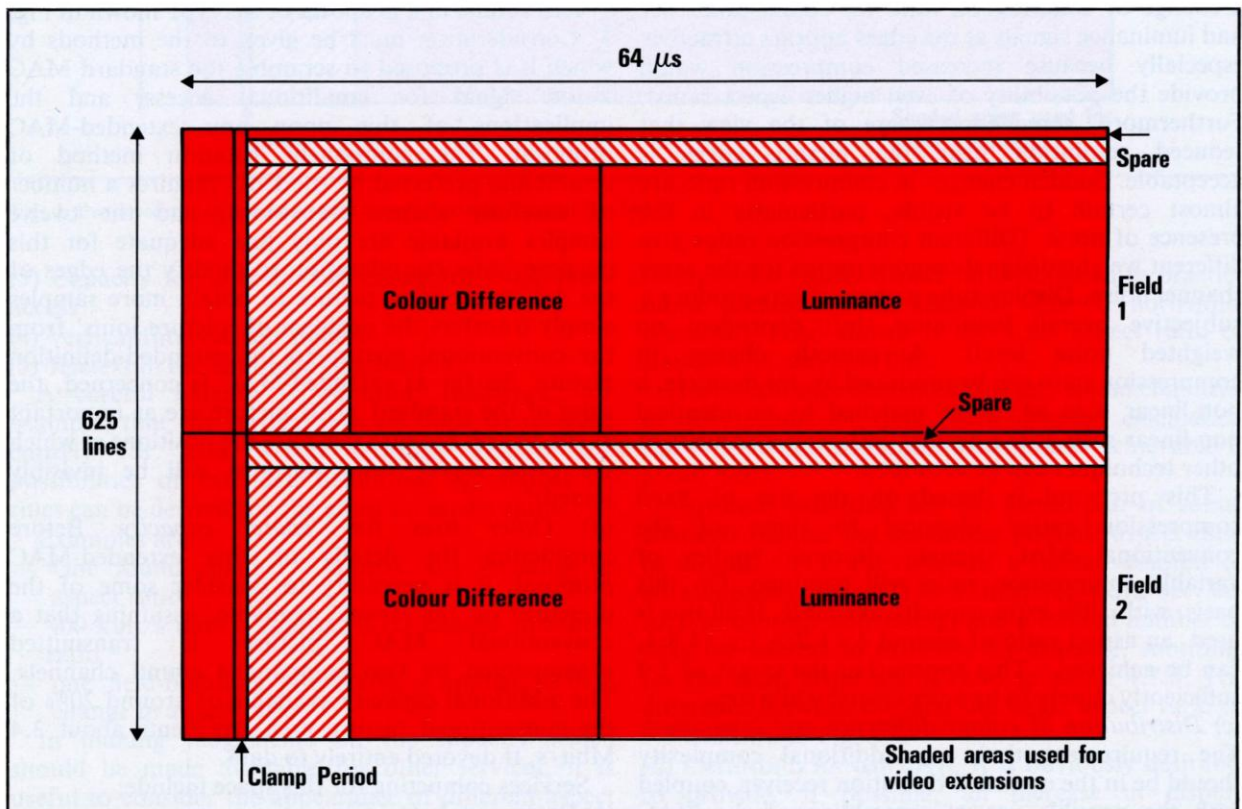

Fig. 2. Space available for extended picture with reduced length of data-burst.

identified; 7% in the field-blanking interval and 13% in the data period. This suggests that an increased aspect ratio is clearly feasible. However, this raises a number of important questions.

(*a*) Should the extra signal be conveyed in analogue or digital form?

(*b*) If analogue, should the compression ratios be as for the main picture?

(*c*) Where should the luminance and colour-difference signals be placed and what structure should be used?

(*d*) To what other uses might the 'spare' capacity be put?

(*a*) *Analogue or digital transmission?* The spare capacity of 20% is considered inadequate for conveying the extra picture in digital form. Furthermore, digital signals and analogue signals have quite different noise characteristics so that attempts to join together two parts of a picture, one transmitted digitally and the other part analogue, could lead to visible and annoying joins.

(*b*) *Choice of compression ratio.* The possibilities of a change of compression ratio for colour-difference and luminance signals at the edges appears attractive, especially because increased compression would provide the possibility of even higher aspect ratios. Furthermore, some experts are of the view that reduced resolution near the picture edges is acceptable. Sudden changes in compression ratio are almost certain to be visible, particularly in the presence of noise. (Different compression ratios give different weighted signal-to-noise ratios for the same channel noise. Display-tube gamma effects produce a subjective overall luminance shift dependent on weighted noise level). A smooth change in compression ratio can be produced by, for example, a non-linear scan at source matched by an identical non-linear scan at the display, although a number of other techniques can be identified.

This proposal is based on the use of fixed compression ratios identical to those of the conventional MAC signal, although studies of variable compression ratio will continue. On this basis, with 20% extra capacity available, if all this is used, an aspect ratio of around $4 \times 1.2:3$, i.e., 4.8:3, can be achieved . This approaches the target of 5:3 sufficiently closely to be a very worthwhile step.

(*c*) *Distribution of colour-difference and luminance.* The requirement that any additional complexity should be in the extended-definition receiver, coupled with the possible use of scrambling of the MAC signal, poses serious problems. The problem of

scrambling is that the edges of the 4:3 aspect ratio picture, to which the wide aspect ratio strips must be joined, occur in the middle of the picture when scrambled. If the extra strips are joined in the most efficient manner, then the conventional 4:3 aspect ratio receiver is required to have extra line storage and complexity which should be avoided if possible.

This proposal provides a method by which the 4:3 aspect ratio scrambled picture remains completely untouched and the extra signals are conveyed in the line or frame blanking periods.It is noted that the extra space available in the line-blanking periods is about 13%, and that available in the frame-blanking period is 7%, a ratio of about 2:1. The luminance compression ratio is 3:2 and the colour-difference compression ratio is 3:1; so that, with luminance occupying twice the capacity of the colour-difference, it is logical to put the extra luminance signals on the appropriate lines and the extra colour-difference signals into the field-blanking period. Both signals use the same compression ratios as with standard MAC.

This results in a proposal of the type shown in Fig. 3. Consideration must be given to the methods by which it is proposed to scramble the standard MAC vision signal for conditional access, and the implications of this upon any extended-MAC proposal. The component rotation method of scrambling preferred by the EBU requires a number of carefully shaped transitions, and the twelve samples available are only just adequate for this purpose. Any consideration to modify the edges of the 4:3 aspect ratio picture to obtain more samples simply transfers the problem of 'picture joins' from the conventional picture to the extended-definition picture. So far as extended-MAC is concerned, the sides of the standard MAC picture are as important as the centre, because these are the positions at which the extra aspect ratio portions will be invisibly joined.[2]

(*d*) *Other uses for 'spare' capacity.* Before considering the details of this extended-MAC proposal, it is necessary to consider some of the pressures on the 'space' available, assuming that a conventional MAC picture is transmitted accompanied by two companded sound channels. The additional capacity available of around 20% of the conventional picture area represents about 3.4 Mbit/s, if devoted entirely to data.

Services competing for this space include:
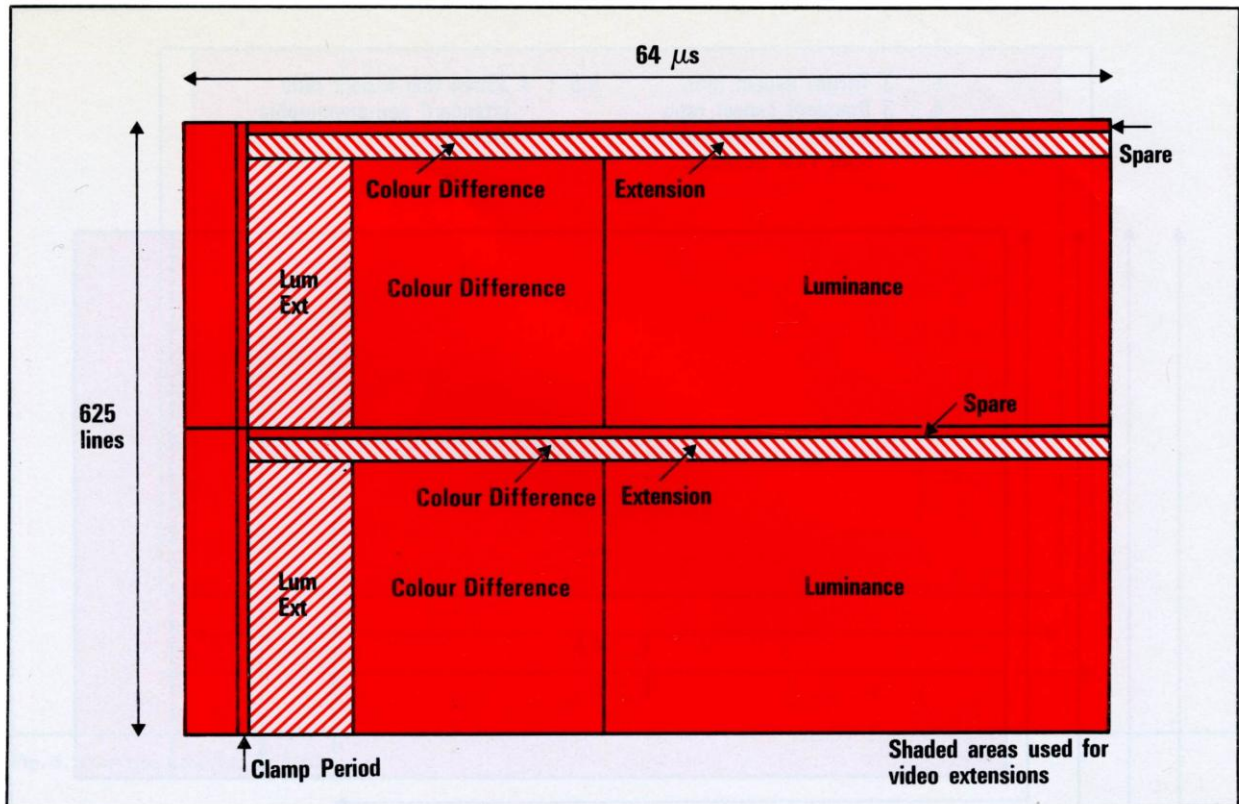
(1) Extra sound channels

(2) Extra data channels

Fig. 3. Proposed use of transmitted frame for extended-definition MAC.

(3) Capacity for over-air addressing for conditional access

(4) Vertical Interval Test signals

(5) Teletext in the field-blanking interval.

A careful balance is essential. Insistence, for example, that the vertical interval must be reserved entirely for data would seriously restrict the possibilities of extended definition. A number of rules can be derived for the effect on aspect ratio.

Examples are:

— One sound channel - approx. 0.1:3 change in aspect ratio

— 400 kbit/s data - approx. 0.1:3 change in aspect ratio

— one field-blanking line/frame - approx. 0.01:3 change in aspect ratio

In making judgements on the capacity which should be made available for other services, it is useful to consider the appearance of different aspect ratios (see Fig. 4). This figure shows the aspect ratio proposed by the NHK[2] (5:3), the current 4:3 aspect ratio, and a typical aspect ratio obtained in practice on a domestic PAL receiver (due to horizontal overscan). Also shown is the 4.5:3 aspect ratio of standard 35 mm cine film.

If no allowance were made for any sound channels, or for teletext or data, then detailed calculation shows that the maximum aspect ratio achievable is about 5.0:3.

However, provision for one stereo pair of sound channels reduces the maximum possible aspect ratio to around 4.8:3. Provision of a limited amount of data capacity (about 140 kbit/s) for extra services such as over-air addressing, and a limited number of lines for teletext to provide, for example, subtitling for the deaf, reduces this ratio to about 4.7:3. The difference between this and the target aspect ratio of 5:3 is shown in Fig. 5.

(ii) EXTENDED BANDWIDTH. It is obviously desirable to provide, if possible, an increase in display resolution to accompany the proposed increase in aspect ratio.
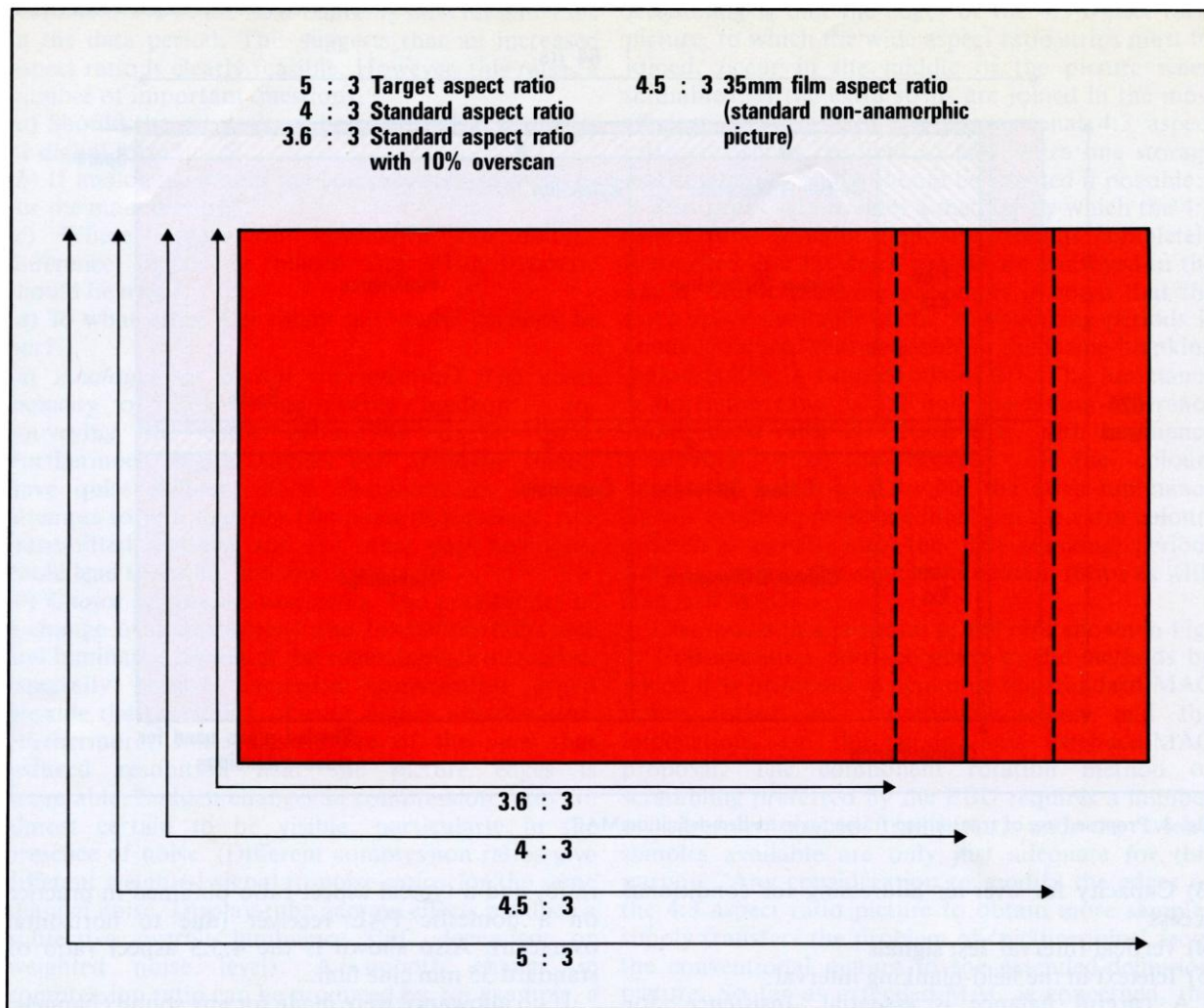
Fig. 4. Comparison of aspect ratios.

Increased vertical resolution in colour-difference and luminance components can be achieved by picture-processing techniques.

Increased horizontal resolution requires additional baseband bandwidth. This might be feasible since MAC has no subcarriers and, with the pre-emphasis network currently in use, a considerable margin of safety exists in adjacent-channel interference performance.

It has been found from current work at the UKIBA and elsewhere[3] that a modulating signal bandwidth of the order of 11-12 MHz can be considered. This would allow a luminance bandwidth of about 7.5 MHz, a very useful improvement which would result in picture spatial resolution in the horizontal direction approaching that of the NHK 1125-line proposal.

Such an increase in bandwidth obviously requires a change in sampling frequencies used for generation of the time-compressed vision signal. However, whether or not to take advantage of this improved bandwidth at the receiver would be a manufacturer option, the signal being analogue in form.

Having discussed the possibilities for extending the C-MAC signal to a wider aspect ratio, a specific proposal will now be made.
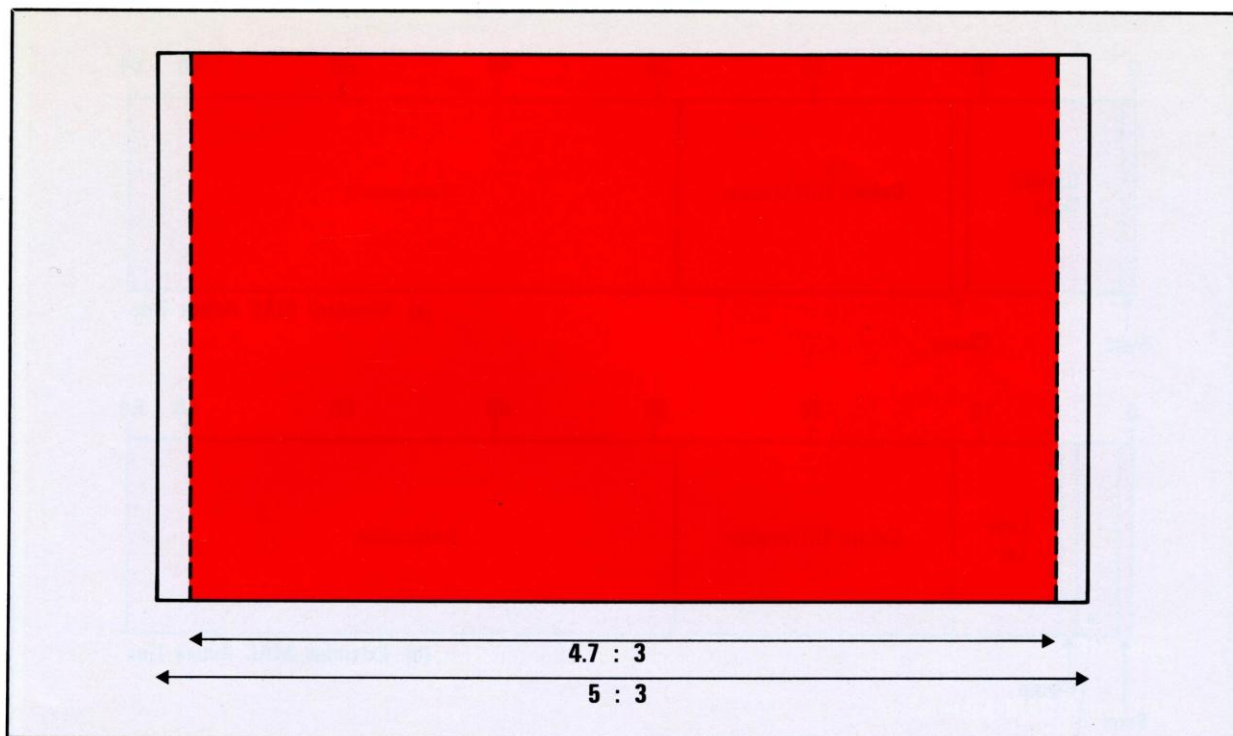
Fig. 5. Proposed aspect ratio 4.7:3.

THE EXTENDED-DEFINITION MAC PROPOSAL

This specification proposes a new signal format — E-MAC, having an aspect ratio of 4.6875:3, but having total compatibility with the standard 4:3 aspect ratio C-MAC/packet signal.

Structure of the Time Division Multiplex

The main features of this proposal are shown in diagrammatically in Fig. 6. For the purposes of discussion, the luminance and colour-difference signals can be considered as being divided as follows (see Fig. 7):

Luminance has 4 parts:

L0   left edge of wide picture

L1 ⎫
L2 ⎭   scrambled parts of 4:3 picture

L3   right edge of wide picture.
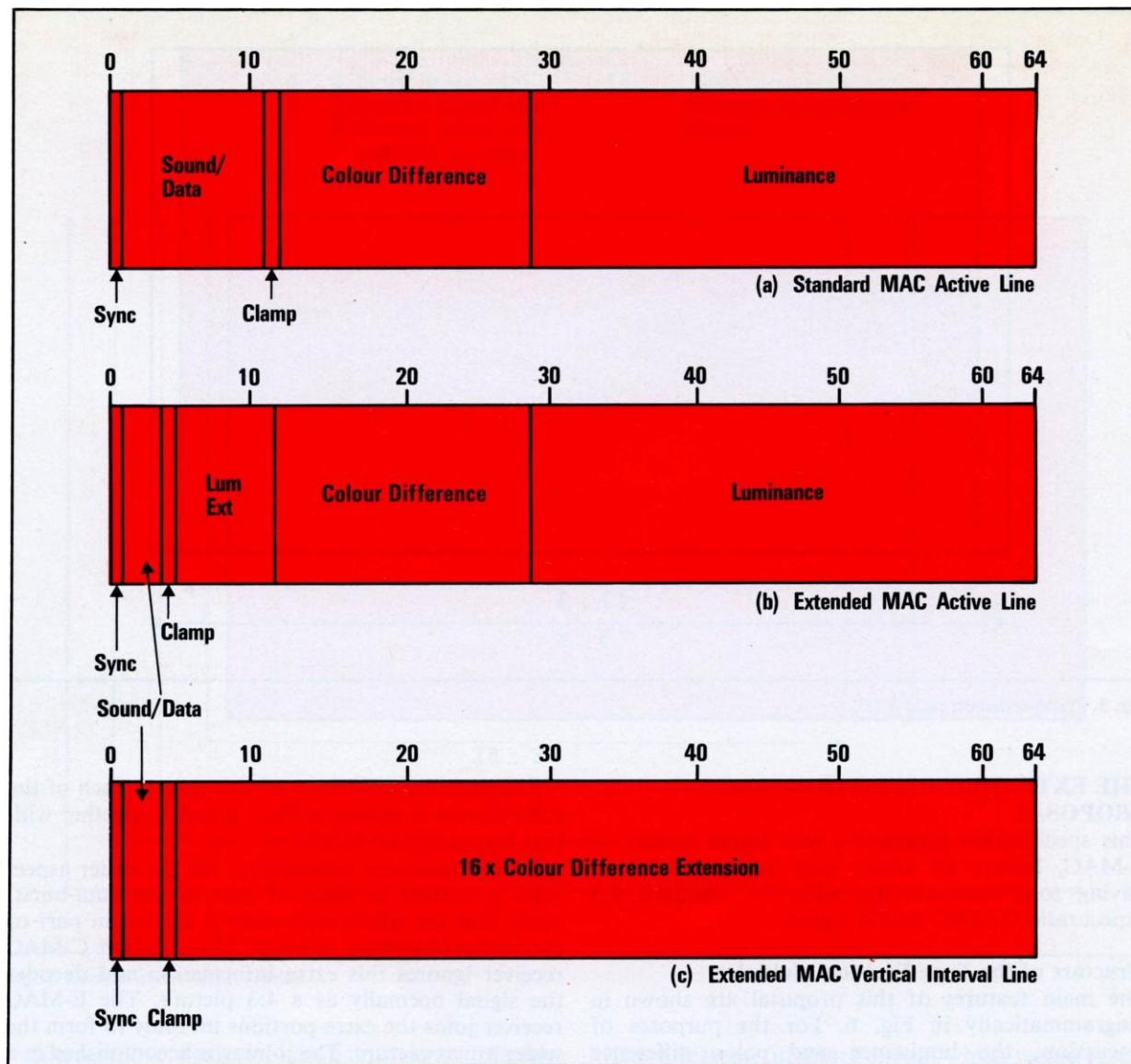
Similarly for colour-difference:

C0   left edge of wide picture

C1 ⎫
C2 ⎭   scrambled parts of 4:3 picture

C3   right edge of wide picture.

The nominal allocation of line time to each of the components is shown in Figs. 6 and 7, together with that for scrambled MAC.[2]

Extra luminance information for the wider aspect ratio is carried in place of part of the data-burst, while that for colour-difference is carried in part of the vertical-blanking interval. The standard C-MAC receiver ignores this extra information and decodes the signal normally as a 4:3 picture. The E-MAC receiver joins the extra portions invisibly to form the wider aspect picture. The joining is accomplished in a similar way to that required in the 4:3 picture descrambling process and is very resistant to channel imperfections such as noise, non-linearity and timing errors.[2]

The C-MAC specification[1] caters for the possibility of a data-burst of variable length, with the vision clamp period specified always to immediately follow the data. In the proposed E-MAC luminance line this is the case.

The E-MAC colour-difference lines are transmitted during part of the vertical interval (see Fig. 7b). Each of these lines carries extended colour-

Figs. 6a, 6b and 6c: Transmitted lines showing the time-division multiplex: a: standard C-MAC active line; b: E-MAC active line; c: E-MAC lines during the vertical interval.

difference information from 16 picture lines. There are thus 18 extended colour-difference lines in each vertical-blanking period ($16 \times 18 = 288$; the number of active picture lines per field).

Aspect Ratio Pan Control

It is important that the standard-aspect-ratio viewer sees the 'correct' portion of the wider-aspect-ratio picture - that is, the part containing the subject of interest at the time. For this reason, the amounts of left and right 'sides' of picture transmitted in the E-MAC signal are variable (Fig. 8). This allows the 4:3 picture full compatibility with the wider aspect ratio source. The proportions of left and right extended picture being transmitted can be signalled in the TDM control line (line 625) for use by the E-MAC
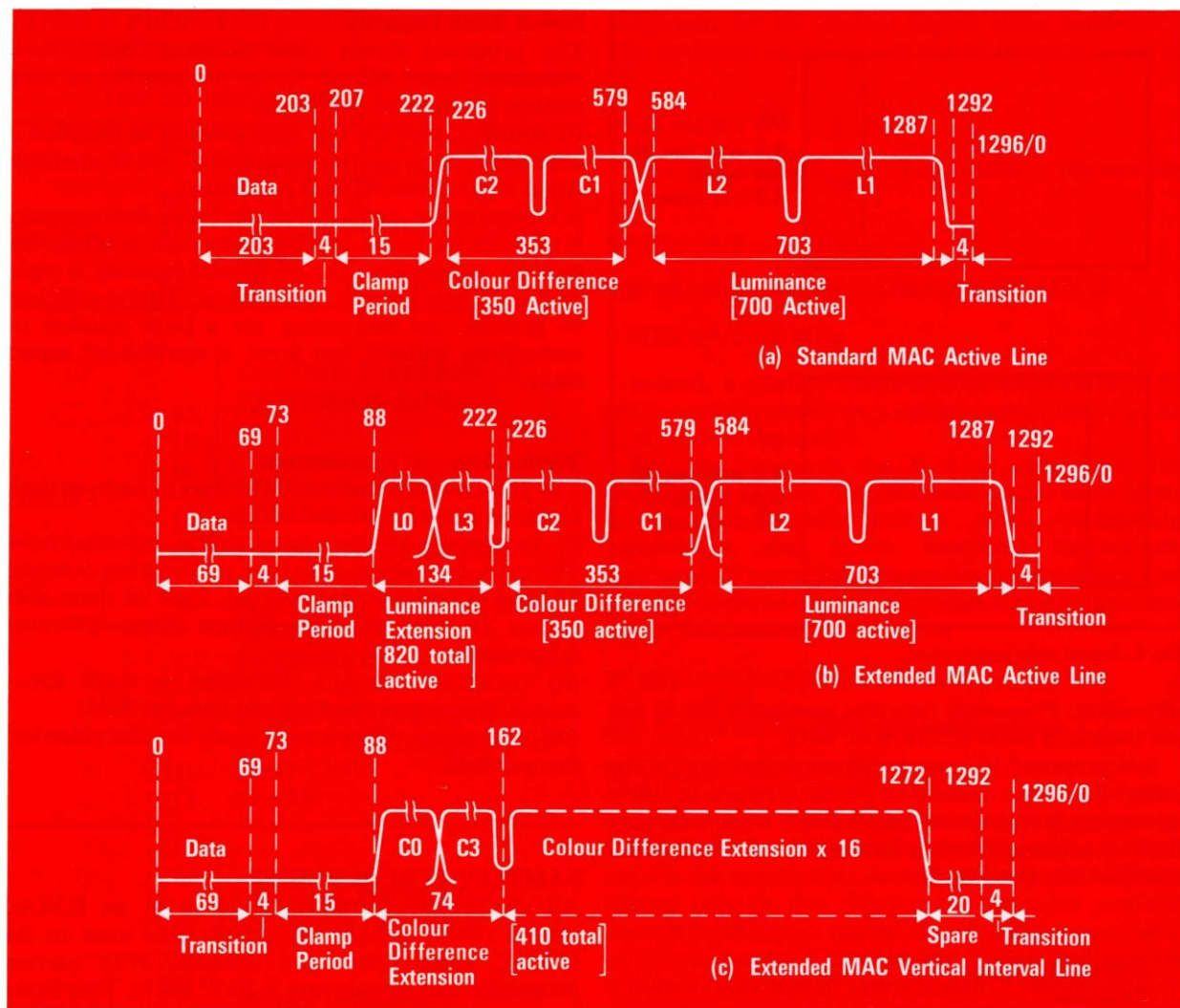
Fig. 7a, 7b and 7c: Transmitted lines showing sample numbering: a: standard C-MAC active line; b: E-MAC active line; c: E-MAC lines during the vertical interval. Note: The sample numbering shown here may vary slightly from the eventual proposal.

receiver. If the assumption is made that the pan cannot occur at high speed (as this would cause discomfort to the 4:3 aspect viewer) then the amount of capacity required for this data is minimal.

Amplitude/Frequency Characteristics(Uncompressed)
(i) LUMINANCE. Maximum amplitude 1 V p-p. Frequency response nominally flat to not less than 5.5 MHz (CCIR Rec. 601). Investigations are in progress towards the provision of a wider bandwidth

by the use of a wider compressed-signal bandwidth. The increase available is dependent on adjacent channel interference considerations, there being no subcarriers to limit the increase.

Current work suggests that a compressed signal bandwidth of 11-12 MHz is possible. This would provide about 7.5 MHz of luminance bandwidth. Use of dynamic limiting[4] might be necessary to achieve this increase.
(ii) COLOUR-DIFFERENCE COMPONENTS. Amplitude: 1.3 V p-p (± 0.65 V) corresponding to 100% peak
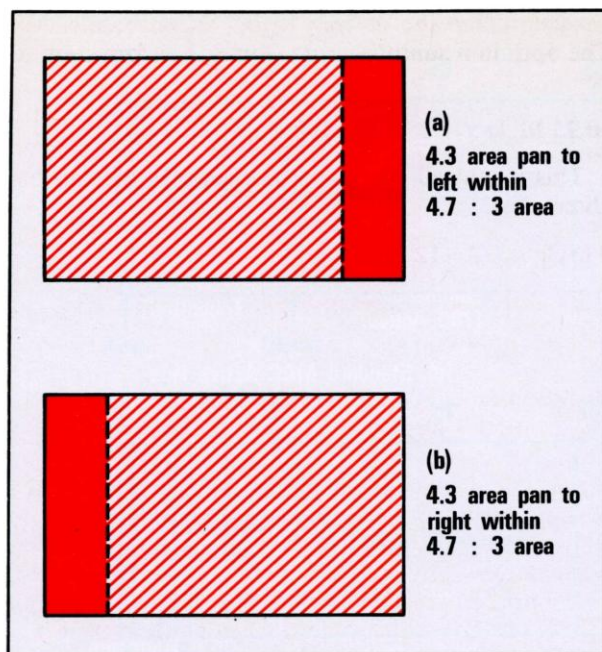
Fig. 8. Aspect ratio pan control.

saturation. Frequency response nominally flat to not less than 2.75 MHz (CCIR Rec. 601).

It is proposed to provide 'dynamic limiting' in the colour-difference channel to permit a return to 100% saturation transmission capability,[4] while allowing the full colour-difference bandwidth of the C-MAC specification[1] (see Fig. 9).
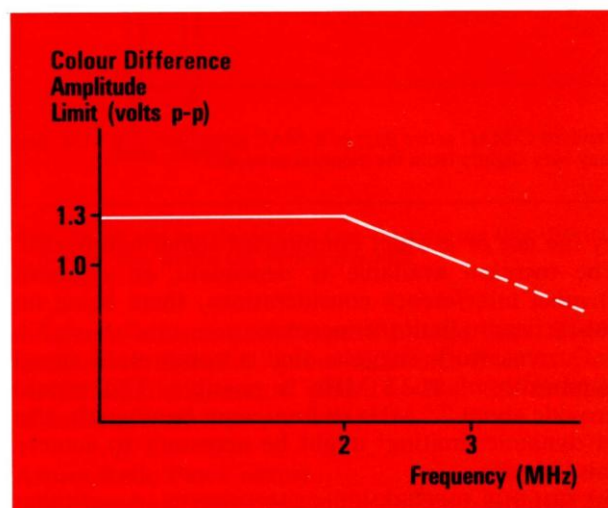

Fig. 9. Colour-difference limiting.

Sound/Data Capacity

The proposed aspect ratio increase results in a reduction, from 162 to 50, in the number of data packets transmitted per frame.

(i) SOUND CAPACITY. The data channel as specified is capable of carrying two companded sound channels (total requirement 42 packets/frame).

(ii) ADDITIONAL DATA CAPACITY. Some data capacity is reserved for future developments such as subscriber over-air addressing. The additional capacity is eight packets/frame (approx. 140 kbit/s). This is sufficient to provide fast addressing for a large number of subscribers without too great a sacrifice of aspect ratio.

Vertical Interval Specification

The proposed assignment of the lines in each vertical-blanking period is set out in Table 1.

(i) EXTENDED COLOUR-DIFFERENCE INFORMATION. The extended colour-difference information occupies 18 lines in each vertical interval. Each of these lines carries 16 lines of wider-picture colour-difference information.

(ii) TELETEXT SIGNALS. Provision is made for 4 standard or compressed teletext lines per field.

(iii) TEST LINES. Allowance is made for one video test line per field.

SAMPLING FREQUENCIES

All the sampling frequencies used in an E-MAC system centre around the sample rate used in the C-MAC video coder and decoder. With current proposals, this sample rate is 20.25 MHz. This figure is particularly convenient for two reasons. Firstly, the agreed studio standard sampling rates of 13.5 MHz for luminance and 6.75 MHz for colour-difference components (CCIR Recommendation 601) give rise to a sample rate of 20.25 MHz after 3:2 and 3:1 compression respectively. Secondly, the rate is the data rate used in the data part of the C-MAC transmission scheme. However, a sampling rate of 20.25 MHz implies a limitation on video bandwidth of around 9 MHz in the satellite channel, allowing for filter headroom. Taking compression into account, this results in a baseband luminance bandwidth limitation of around 6 MHz.

Since it seems likely that the satellite channel could accommodate more video bandwidth, and since extra luminance resolution would be desirable for an

TABLE 1: PROPOSED ASSIGNMENT OF LINES IN VERTICAL INTERVAL

	LINE NO.	ASSIGNMENT
	622	LAST PICTURE LINE (GREY + LUMINANCE)
	623	TEST LINE
FIELD 2	624	COHERENT DETECTION LINE
	625	FRAME SYNC & TDM
	1	
	2	
	.	COLOUR-DIFFERENCE
	17	EXTENSION LINES
	18	
	19	
FIELD 1	.	SPARE (POSSIBLY TELETEXT)
	22	
	23	FIRST PICTURE LINE (CHROMA + BLACK)
	24	FULL MAC VIDEO WITH LUMINANCE EXTENSION
	.	
	310	LAST PICTURE LINE (GREY + LUMINANCE)
	311	TEST LINE
	312	SPARE
	313	
	314	
	.	COLOUR-DIFFERENCE
	329	EXTENSION LINES
	330	
	331	
FIELD 2	.	SPARE (POSSIBLY TELETEXT)
	334	
	335	FIRST PICTURE LINE (CHROMA + BLACK)
	336	FULL MAC VIDEO WITH LUMINANCE EXTENSION

headroom for the desired higher video bandwidth. The optimum *sampling rate* would therefore seem to be:

$$20.25 \text{ MHz} \times 4/3 = 27 \text{ MHz}$$

This would allow *video bandwidth* in the satellite channel of:

$$9 \text{ MHz} \times 4/3 = 12 \text{ MHz}$$

and an *uncompressed* luminance bandwidth of:

$$6 \text{ MHz} \times 4/3 = 8 \text{ MHz}$$

Indeed, a satellite channel video bandwidth of 12 MHz would probably be a realistic upper limit for the 27 MHz FM channel.

For the inputs to the E-MAC coder, and the outputs for display, the increased aspect ratio needs to be taken into account when considering bandwidths and hence sampling frequencies. Appropriate sampling frequencies for the input and output baseband digital components would therefore be, for luminance:

$$27 \text{ MHz} \times 2/3 \times 5/4 = 22.5 \text{ MHz}$$

and for the colour-difference components:

$$27 \text{ MHz} \times 1/3 \times 5/4 = 11.25 \text{ MHz}$$

This assumes a conventional active-line time for the wider aspect ratio signals. In these equations the first ratio is the appropriate decompression ratio, and the second ratio is that relating the extended and the conventional aspect ratios. An extended aspect ratio of 5:3 is assumed here as the source and display standard, although in transmission the aspect ratio is reduced to 4.7:3. For sources or displays with twice the conventional line rate (see Figs. 10 and 11) these sampling frequencies would be doubled, and the source ADC and display DAC sampling rates would be 45 MHz for luminance and 22.5 MHz for each colour-difference component.

Although the sample rate in the MAC video coder has here been increased from 20.25 MHz to 27 MHz, this does not affect compatibility with MAC decoders based on the 20.25 MHz rate. This is because the MAC video transmission is, of course, analogue. Hence, decoding with a lower sampling rate than that used in coding would simply limit proportionately the available video bandwidth.

The sampling frequencies envisaged are set out in Table 2.

extended-quality service, higher sampling frequencies in the MAC video channel are being considered.

It is very desirable to relate any new MAC sampling rate to the present 20.25 MHz by a simple integer relationship. On the other hand, practical considerations would dictate that the sampling rate be kept as low as possible while providing filtering
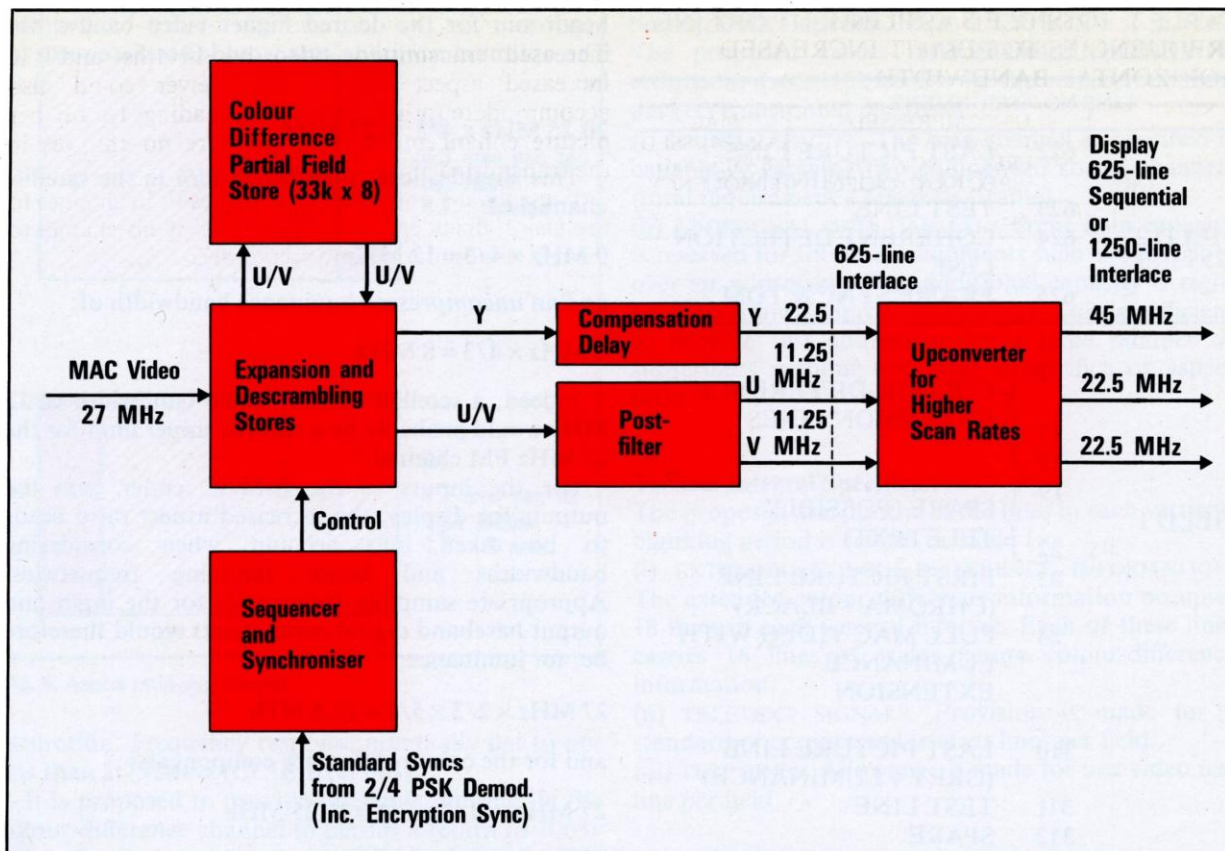
Fig. 10. E-MAC vision decoder showing possible sampling frequencies.

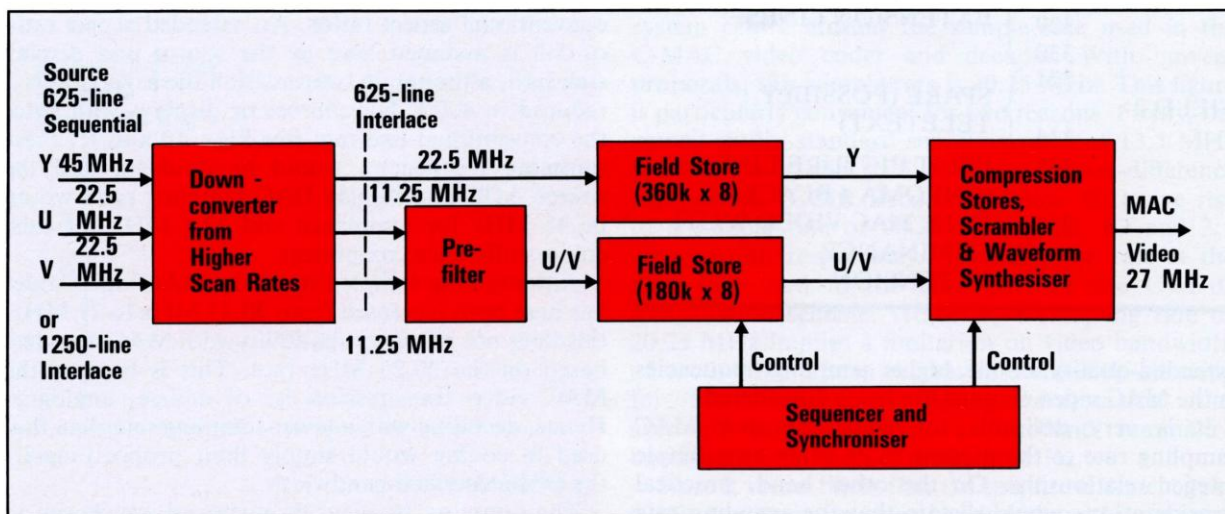**Fig. 11.** E-MAC vision coder showing possible sampling frequencies.

TABLE 2: POSSIBLE SAMPLING FREQUENCIES TO PERMIT INCREASED HORIZONTAL BANDWIDTH

LINE STRUCTURE	UNCOMPRESSED SAMPLING FREQUENCY FOR ASPECT RATIO OF:		MAC COMPRESSED SAMPLING FREQUENCY
	4:3	5:3	
625 Lines Interlace 2:1	18 MHz	22.5 MHz	27 MHz
1250 Lines Interlace 2:1	36 MHz	45 MHz	—

RECEIVER IMPLEMENTATION

Compatibility

A special receiver will be required to decode E-MAC signals. This will need to be capable of decoding and displaying the E-MAC signals and the standard MAC signals. The type of transmission would be indicated by a 'flag' sent in the TDM control line. The receiver would then switch between the required types of decoding in accordance with this flag.

Decoding and display of a standard MAC signal on an E-MAC receiver would result in a picture of standard 4:3 aspect ratio. Presumably, the receiver would blank the edges of the picture and maintain the standard picture in the centre of the display.

To maintain compatibility, all types of receiver will be required to receive all types of transmission, although not all of the transmitted information might be decoded. This will enable the standard MAC receiver to accept the E-MAC transmissions but to display only the standard (4:3) part of the vision.

To ensure compatibility, the receiver must take account of, and use, any relevant information which is sent in the TDM control line. For example, all receivers must be able to move their video clamp position relative to the received synchronisation, according to the requirements of the transmitted signal. The clamp period is defined as remaining fixed with respect to the end of the data-burst and, therefore, its position within the video line is dependant on the size of the burst, which is coded in the TDM control line.

The E-MAC Receiver

In addition to performing all the functions of the standard MAC receiver, the extended-definition MAC receiver would have the ability to use the increased transmitted video bandwidths and the increased aspect ratio. The receiver could also accommodate other processing leading to further picture enhancements which require no changes in the transmitted signal.

These extensions to the receiver result in changes to the vision decoder but require little or no change to the r.f. demodulation and sound decoding.

The E-MAC system would lend itself to viewing on high-resolution, large-screen displays at short viewing distances around 2-3 times the picture height. As a result, noise on the picture would become more apparent. Generally, it is expected that E-MAC receivers would be used in areas within the transmission 'footprint' and/or that the signals would be received with larger dishes, to achieve the better picture quality resulting from high carrier-to-noise ratios.

Reception of signals with lower C/N ratios could result in threshold effects which would also be objectionable on extended displays. Threshold effects can, however, be greatly reduced by using a Phase-Locked Loop video demodulator.

The Vision Decoder

The basic blocks of the E-MAC vision decoder are illustrated in Fig. 10. Complexity in the decoder is kept, where possible, to a minimum by processing in the coder (see Fig. 11). The system is controlled by synchronisation derived from the data-burst and the TDM control. This includes the standard line sync., frame sync., 20.25 MHz clock, encryption sync., clamp position (size of data-burst), start of luminance and colour-difference, and the pan control. The pan control is required to reassemble the extensions in the correct proportions around the standard picture.

The technology used in the extended receiver would need to be digital due to the amounts of processing and storage required. The use of high-quality displays might lead to the necessity for 8-bit digitisation of the vision signal, and the complexity of processing might require greater than 8-bit words within the decoder to maintain accuracy.

As previously shown, the ability of the decoder to use the increased transmission bandwidths leads to the need for a sampling frequency of 27 MHz. After sampling and digitising, the video is descrambled, expanded and reorganised to generate the coherent, wide aspect ratio, component signals. Storage is required for all of these processes; two lines of

storage for the luminance, two lines for the colour-difference and a partial field store for the colour-difference extensions transmitted in the vertical interval. (It is intended, in order to simplify decoding, to transmit the colour-difference extensions in the vertical interval preceding the field to which they refer). The number of active samples in the extended video line is increased due to the higher sampling rates to 1094 for luminance and 547 for colour-difference. The partial field store has to store 18 lines of 16 extensions, each containing 100 samples, i.e., a capacity of 28,800 bytes.

The video data can be descrambled either before or after the expansion process. The former requires processing at the 27 MHz rate whereas the latter, although it requires processing at the lower rate of 22.5 MHz, needs more storage for the edges of the video to ensure error-free descrambling.

Picture errors in the decoder are likely to be caused by timing inaccuracies, which could result in three main problems:
(*a*) Chrominance-luminance differential delay
(*b*) Descrambling errors (seen as random dots on picture)
(*c*) Picture extension errors (seen as vertical picture errors at the edges of the video).

The signal is, however, configured in such a way that all these potential problems can be eliminated.

Colour-difference Post-Filter
The colour-difference post-filter employed in the standard MAC receiver is a 1:2:1 type. This vertical digital filter has a response with a null at the sampling frequency, i.e., line rate.

Adoption of a more complex post-filter could lead to improvements in the vertical colour-difference frequency response. The pass-band response could be made slightly flatter and the bandwidth increased, but a steeper roll-off could lead to problems of ringing on sharp horizontal colour edges. The area that is most likely to be improved is the rejection of alias components by increased attenuation close to the sampling rate.

The design of a filter to improve on the 1:2:1 type will require further investigation, but it is likely that it will need more processing. For example, a seven-tap filter will use six lines of delay in the filter and will also result in the need for two compensating lines of delay in the luminance channel, since only one line of delay is offset in the coder (see Figs. 10 and 11).

Alternatively, a more complex two-dimensional post filter may be employed if colour-difference

vertical resolution enhancements are introduced in the coder.

Display Processing
The E-MAC signal could be decoded and displayed with a 625-line, interlaced scan; but, since displays will be redesigned to accommodate the increased aspect ratio, they should also be designed to use higher scan rates and so reap the benefits of other decoder enhancements.

Double line-rate scans, in the form of either 625-line 50 Hz non-interlace, or 1250-line 50 Hz interlace, help to reduce flicker problems and to improve the displayed vertical resolution. Both systems have a 31250 Hz line rate and therefore lead to sampling rates of up to 45 MHz in the processing.

The up-converter uses processing which includes a number of fields of delay. This could generate a significant absolute delay in the video signal which might require delay compensation in the sound at the receiver.

Teletext
Allowance has been made in the proposed system to transmit Teletext on four of the vertical-blanking interval lines. This has the advantage that standard Teletext decoding can be used in the receiver.

The luminance channel can be used directly for Teletext transmission to carry complete lines. The colour-difference channel can also be used to send half lines, which, for this proposal, results in two extra transmitted lines. These extra lines need to be stored at the receiver so that they can be presented to the Teletext decoder at the correct rate after the normal lines have been processed. To achieve this, two lines of storage are required in the vision decoder. These extra Teletext lines can therefore be received and decoded with only a small amount of extra processing and two lines of storage, resulting in capacity for six complete Teletext lines per field.

CONCLUSION
The signal proposed, E-MAC, provides a compatible extension in vision aspect ratio and resolution to the approved C-MAC/packet signal, while retaining sufficient data capacity to provide one stereo pair of sound channels. Capacity is also provided to permit the transmission of Teletext, and there is a limited-capacity data channel for the transmission of peripheral services such as subscriber over-air addressing. The proposed format has been chosen so

as to minimise the amount of processing required at the increased aspect ratio receiver, while requiring no modification for reception on standard 4:3 aspect ratio receivers. The system in its most advanced form provides pictures of aspect ratio and resolution comparable to those of the NHK 1125-line HDTV proposals.

References
1. 'Television Standards for 625-line 12 GHz Satellite Broadcasting', *EBU Document SPB 284*.
2. N. Lodge, 'Vision Scrambling - A Proposal for the EBU Specification', *IBA E & D Report 122/83*.
3. P.A. Ratliff & A. Oliphant, 'Consideration of Improved Quality Sound and Vision for Satellite Broadcast Service in the UK', *IBC 82 Proceedings* pp. 174-177.
4. M.D. Windram & R. Morcom, 'The MAC Colour-Difference Signal', *IBA E & D Report 124/83*.

CORNELIS GREEBE was born in 1931 in Zaandam, the Netherlands. He studied Physics at Groningen University and subsequently joined Philips Research Laboratories in 1958. Initial work there was in the field of transistor physics, which led to a Ph.D. in 1962. After this his interest shifted first to electron-phonon interactions in piezoelectric semi-conductors, to plasma phenomena in solids and in liquid metals, and then to acoustic surface waves. In 1972 he became director of the Institute for Perception Research in Eindhoven. In 1975 he returned to Philips Research Laboratories as director for consumer electronics.

LEENDERT VAN DE POLDER was born in Nieuwenhoorn, the Netherlands, on 9th July 1928. In 1947 he joined the Philips Research Laboratories, where he worked on black and white television; a European version of the NTSC-system; parametric amplifiers; the discharge mechanism of the Plumbicon pick-up tube; the colorimetry of pick-up tubes; the index tube and the conversion of the videophone signal to the normal broadcast standard, and vice versa. He is currently involved as a senior engineer in high-quality television systems and the international standardisation of television systems.

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Consumer Displays for Hi-Fi Television

by C.A.A.J. Greebe, L.J. van de Polder and S.L. Tan

Synopsis

The capacity of any new broadcast system must be related to the availability of suitable large-screen displays - there is scarcely any purpose in designing a new transmission system which offers greater resolution than can be reproduced by domestic displays, or which the eye is unable to resolve on a small screen at typical domestic viewing distances.

The availability of large-screen displays is therefore seen as a key factor in any move towards a higher-definition system. This chapter discusses the desirable features of domestic large-screen displays, and considers the various options and practical limitations of current display devices.

The contents of this chapter are based upon a paper first presented at the 13th International Televison Symposium, Montreux, May 1983.

INTRODUCTION

The scanning standards for black-and-white television were developed during the late 1940s, while the coding methods for colour television used by European countries were standardised during the sixties. Many broadcast engineers now feel that the time has come to move away from the shortcomings of the present systems, and to offer to the viewer a further advance in picture quality. The term 'hi-fi TV' is used here to refer to a television system with a higher than conventional resolution and a larger display screen, combined with an overall improvement of other picture-quality related aspects such as large-area flicker and cross-colour.

A new approach now seems possible, given the advances which have taken place since the introduction of colour television. For the colour television receiver the developments of the last fifteen years have made it possible to fully transistorise all electronic circuits, to replace discrete components with integrated circuits, and to add complex new functions such as remote control and teletext. Digital processing associated with the use of frame-store memories in receivers is no longer merely a broadcast engineer's dream, but is well within the realm of possibility. Indeed, the technology for digital video processing within the receiver at reasonable cost already exists, and the first of a new generation of such receivers will soon begin to become available.

In recent years much research has been directed towards the development of new systems to provide better pictures - variously described as 'extended-definition', 'enhanced-definition' or 'high-definition'. Nevertheless, the prime goal may be described as 'to enhance the viewing experience'.[1]

If it is assumed that, with the introduction of any new type of display in the average domestic living room, the viewer is unlikely to prefer any significant change in seating distance, it follows that a larger viewing angle is possible only if the size of the display screen is enlarged.

TOWARDS A HI-FI CONSUMER DISPLAY

In their preliminary studies, Philips have assumed the following main objectives for a hi-fi colour TV display:

picture area	0.5 m²
peak brightness	400 cd/m²
contrast ratio (large area)	50:1
resolution (50% modulation transfer function [MTF] at 50% brightness)	800 lines

Furthermore, colour reproduction, convergence, colour purity, picture geometry and grey-scale tracking should all be either equal to, or better than, that which is possible with conventional cathode-ray tube displays.

In addition to these quality-related parameters, when considering the domestic environment, certain other factors must be taken into account: namely the size of the cabinet, weight, the total power consumption and, last but not least, the cost.

There are many different types of display devices and the following have been considered:

(1) direct-view tubes
    (*a*)   enlarged shadow mask tube
    (*b*)   index tube
    (*c*)   channel plate tube
(2) flat panels ('picture-on-the-wall')
    (*a*)   liquid crystal display (light modulator type)
    (*b*)   gas discharge display
    (*c*)   multi-cathode systems
(3) projection systems (optical enlargement)
    (*a*)   conventional projection TV
    (*b*)   banana-tube display system
    (*c*)   light-valve projection display (e.g., Eidophor.)

A first approach might appear to be to produce a larger conventional shadow-mask tube. However, this can lead to unacceptable increases in physical size (depth), weight and required EHT voltage. In practice, the screen diagonal must be limited to about 35 inches (0.89 m).

The 'picture-on-the-wall' has for many years been a goal of television engineers. Nevertheless, satisfactory results have yet to be demonstrated even for conventional television systems. General problems are uniformity and the addressing of the separate picture elements. Furthermore, in the case of liquid crystal displays, the speed of response is too low for high-quality applications, whereas the problem with gas discharge displays is the low lumen efficiency.

Of the various projection schemes, only conventional projection television can at present be considered a serious candidate for a consumer display. The available light-valve projection systems are expensive and are not expected to meet the requirements of a domestic market.

PROJECTION TELEVISION

In a domestic living room it is highly desirable that the television apparatus should be compact, and that it should be a one-piece unit. Accepting this as a starting point, it follows that the optical path from the imaging devices to the separate display screen should be as short as possible.

In principle, this requirement could be met by coupling the cathode-ray tubes and the output screen with optical fibre light guides: Increased spacing between the optical fibres at the display screen would provide picture magnification. Whether this method could lead to a practical solution remains to be demonstrated.

The conventional approach is that the cathode-ray

tube pictures are imaged onto the display screen through a lens system via flat mirrors.

In a living-room environment dust can fall onto these mirrors if they are exposed. This can be avoided if the complete optical path is enclosed within the apparatus, with rear-projection onto the display screen. A practical projection system for a hi-fi TV display would therefore include:

(1) three cathode-ray tubes, one each for red, green and blue
(2) a lens system for each of these tubes
(3) one or more flat mirrors
(4) a rear-projection screen.

The Projection Tube

The requirements of the display tube are: improved resolution, very high luminance, a maximum EHT of about 30 kV (if higher, the X-ray problem increases drastically) and size of tube plus faceplate as small as possible. (The latter in order to ensure reasonable sizes for the cabinet and lens system).

The combination of these requirements causes two main difficulties: firstly, achieving a sufficiently small spot size and, secondly, the problem of a very high phosphor loading. The latter results in reduced phosphor efficiency. Liquid cooling of the tube screen might alleviate these effects. A second measure is to reduce the excitation time of the phosphors during each scan. This can be achieved by using a 100 Hz field frequency which has the additional advantage of eliminating large-area flicker.

The Lens System

In the early 1950s Philips manufactured a projection receiver using a Schmidt optical system. Since that time the development of spheric and aspheric refractive lenses has been such that lenses are currently preferred to systems which use curved mirrors. However, present lens systems for consumer use show a rather low MTF (modulation transfer function) value, but possibilities for improvement exist; more development work is needed.

The Output Screen

In order to display pictures of sufficient brightness the screen must provide a luminance gain in the direction of the viewer. On the other hand, the area within which the viewer can be seated must not be unduly restricted by the directional properties of the screen. These two conflicting demands result in a compromise between screen gain and viewing angle.

A further important requirement is that the ambient light reflected from the screen should be minimal.

With separate projection tubes for each of the colour primaries, each with its own lens system, the light beams fall onto the screen at slightly different angles. This must not result in colour misregistration, or in any noticeable colour shift if the observer walks across the room.

Furthermore, the viewer should not be able to see the exit pupil of the lenses through the output screen (known as the 'hot-spot').

Nevertheless, in principle, a screen can be designed in such a way that all the requirements stated above are fulfilled satisfactorily.

The Outlook for Projection Television

As has been shown, further studies and developments are still needed. These relate to rear projection, spot-size, phosphor loading, peak brightness, contrast, and design of lenses and screens. A number of improvements seem possible.

To achieve an overall picture quality to better that of present-day shadow-mask tubes, the size of the projection screen must be limited to about half a square metre. It would then be possible to view pictures at normal domestic lighting levels.

The present state-of-the-art is such that the obtainable resolution at the anticipated luminance level will probably be somewhat lower than the original goal of 800 television lines. However, at typical domestic viewing distances, the limited screen area does not result in any imbalance between the resolution of the display system and the resolution capability of the eye.

The advantage of the 0.5 m^2 screen area is that the entire rear-projection system can be contained within a cabinet of reasonable size for the average living room.

CONSEQUENCES FOR THE TRANSMISSION SYSTEM

The preceding exploration of high-quality consumer displays indicates that, for several years ahead, the practicable total screen area will be unlikely to exceed about half a square metre. This holds true for projection television and for shadow-mask tubes.

Table 1 shows various dimensional parameters for a screen with an area of 0.5 m^2. For comparison, figures are also given for the 26″ shadow-mask tube, for a possible 35″ version of that tube and for a 1 m^2

TABLE 1: COMPARISON OF SCREEN PARAMETERS

DISPLAY SYSTEM	26″ CRT	35″ CRT	0.5 m² SCREEN	1 m² SCREEN (HDTV)
ASPECT RATIO	4:3	5:3	5:3	5:3
DIAGONAL (m)	0.66	0.889	1.065	1.506
AREA (m²)	0.2093	0.3487	0.5	1
HEIGHT (m)	0.396	0.457	0.548	0.775
WIDTH (m)	0.528	0.762	0.913	1.291
RELATIVE AREA	1	1.67	2.39	4.78
RELATIVE HEIGHT	1	1.15	1.38	1.96
RELATIVE WIDTH	1	1.44	1.73	2.44

screen for a possible future high-definition system. For the new types of display an aspect ratio of 5:3 is assumed.

Compared to the 26″ tube, the screen area approximately doubles for a screen diagonal of about one metre. A system with a screen area of one square metre shows an increase by a factor of more than four. To provide the same spatial resolution over the larger area results in a requirement for a proportionate increase of the transmission capacity, assuming that the viewing distance remains unchanged.

AN INTERMEDIATE GOAL?

There are three possible approaches to providing the viewer with higher-quality broadcast television pictures:

(a) to exploit the existing transmission systems to the fullest extent

(b) to design a completely new high-definition scanning/transmission system to create fully an enhanced viewing experience (a screen size of, say, one square metre, or more).

(c) to design a transmission system which satisfies, as an intermediate goal, a screen size of, say, half a square metre.

With the first of these approaches all possible measures are taken to improve the picture quality when receiving a signal as transmitted via the existing subcarrier systems NTSC, PAL or SECAM. Use is made of advances in the field of digital techniques and picture memories. (At the International Broadcasting Convention in Brighton, September 1982, Philips demonstrated the use of such techniques for the reduction of large-area flicker, interline flicker, noise, cross-colour and cross-luminance.)

With the second approach the number of picture elements to be transmitted becomes so great that the transmission capacity of a single VHF/UHF or 12 GHz DBS channel would be insufficient. A possibility might be to use two such channels in parallel. However, further studies would be needed before such a two-channel system could be proposed. In order to investigate the possibilities, Philips have developed a number of research tools, including a camera, telecine, projection device, and standards converters, all based on a preliminary scanning standard of 1249 lines.[2] However, with each European country restricted to five channels for 12 GHz DBS, it is doubtful whether a two-channel system would meet with favour. It is likely to be many years before use of the next broadcast band at 40 GHz becomes practicable. Furthermore, for the domestic environment, the production of large-screen displays appropriate to a true high-definition television system does not appear to be imminent.

A third approach, therefore, would be to design a transmission system that offers worthwhile improvements compared to conventional terrestrial systems, and which would be compatible with the European 12 GHz DBS channel assignments.

CONCLUSIONS

For the foreseeable future it has been shown that the largest practicable domestic display device is likely to have a screen area limited to about half a square metre. Compared to a 26″ tube this represents an increase in display area of slightly more than a factor of two. It therefore seems reasonable to consider whether a transmission system using a 12 GHz satellite channel could be devised to match the projected capabilities of such a display.

References
1. R. N. Jackson and S. L. Tan, 'Hi-Fi Television: Towards the Enhanced Viewing Experience', *Montreux 1981*, pp. 224-227.
2. K. G. Freeman, G. de Haan, J. M. Menting and D. W. Parker, 'Experimental Work Towards High Fidelity Television', *IBC 82*, pp. 140-143.

Pourquoi la télévision à haute définition non compatible?

par T. Long

Résumé

On a résumé les différentes exigences pour la réalisation d'une télévision à 'haute résolution', ainsi que les limitations des systèmes de télévision actuels.

Le principe traditionnel de la télévision à haute définition consiste à augmenter le nombre de lignes du système de transmission, en augmentant de cette façon les exigences en largeurs de bande et en donnant lieu à une incompatibilité avec les systèmes actuels.

L'introduction de la radiodiffusion directe par satellite (DBS) au moyen du format MAC offre la possibilité de nouvelles améliorations afin d'obtenir un système à définition prolongée, qui serait en mesure d'offrir une grande partie de la meilleure qualité des systèmes à haute définition sans toutefois présenter une incompatibilité avec le format à 625 lignes ou les propositions actuelles concernant DBS.

Traitement des signaux pour une télévision à définition plus élevée

par G. Tonge

Résumé

Le système MAC offre des progrès dans la qualité de l'image par rapport aux systèmes traditionnels de sous-porteuses. D'autres perfectionnements seront possibles au moyen de techniques de traitement des signaux, et on compare ici les caractéristiques du principe MAC 'à définition prolongée' par rapport aux systèmes à 'haute définition'.

MAC — Définition prolongée

par M. Windram, R. Morcom et T. Hurley

Résumé

'Les avantages qui peuvent être obtenus avec ce principe (MAC) comprennent les possibilités de services à définition prolongée avec un potentiel de visualisation de haute qualité sur des écrans de dimensions plus importantes'. Cette déclaration fut faite dans le cadre du premier exposé publié par l'Independent Broadcasting Authority décrivant le principe MAC en ce qui concerne la radiodiffusion par satellite. en septembre 1981.

On propose de façon spécifique un service MAC à 'définition prolongée' (E-MAC) entièrement compatible avec le MAC traditionnel mais qui exploite la souplesse que l'on trouve dans la spécification du C-MAC. Cette proposition offre la possibilité de rapports de la largeur à la hauteur de l'image et de résolution qui est voisine du système de télévision à haute définition NHK 1125 lignes, sans nécessiter, toutefois, des bandes de fréquence en radiofréquence dont les émetteurs ne pourront disposer de façon pratique, en Europe, que dans 20 ou 30 ans.

Visualisation des consommateurs pour la télévision à haute fidélité

par C. A. A. J. Greebe, L. J. van de Polder et S. L. Tan

Résumé

La capacité d'un système de radiodiffusion doit être en rapport avec la disponibilité de représentations appropriées sur grand écran — il est quasiment impossible de mettre au point un nouveau système de transmission offrant une résolution majeure qui puisse être reproduit par les dispositifs de visualisation domestiques ou que l'oeil ne soit pas en mesure de résoudre sur un petit écran et à la distance moyenne de visualisation domestique.

On estime, par conséquent, que la disponibilité de dispositifs de visualisation à grand écran est un facteur essentiel pour toute recherche d'un système à netteté plus élevée. Le présent chapitre se penche sur les caractéristiques souhaitables de la visualisation domestique sur grand écran tout en étudiant les différentes options ainsi que les limitations d'ordre pratique des dispositifs de visualisation actuels.

Warum nichtkompatibles hochzeiliges Fernsehen?

von T. Long

Zusammenfassung

Es werden die einzelnen Erfordernisse für "hochzeiliges" Fernsehen zusammengefaßt, zusammen mit den Beschränkungen der bestehenden Fernsehsysteme.

Die konventionelle Lösung für hochzeiliges Fernsehen besteht aus einer Vergrößerung der Zeilenzahl der Sendesysteme. Daraus ergeben sich einerseits eine Zunahme in den erforderlichen Bandbreiten und andererseits die Unverträglichkeit mit bestehenden Systemen.

Mit dem Aufkommen des direkten Satellitenfunkes (DSF) im MAC-Format bietet sich die Möglichkeit für weitere Verbesserungen zur Erzielung eines kompatiblen 'höherzeiligen' Systems, das imstande wäre vieles der besseren Qualität der hochzeiligen Systeme zu gewähren, aber ohne die Unverträglichkeit, die sich entweder mit dem 625-zeiligen Format oder den jetzigen Vorschlägen auf DSF einstellt.

Die Signalverarbeitung für höherzeiliges Fernsehen

von G. Tonge

Zusammenfassung

Das MAC-System gewährt im Vergleich mit konventionellen Hilfsträgersystemen Verbesserungen in der Bildqualität. Weitere Verbesserungen lassen sich mit Signalverarbeitungsverfahren erzielen und es wird die Leistung einer 'höherzeiligen' MAC-Lösung mit der von 'hochzeiligen' Systemen verglichen.

Erhöhte Bildschärfe MAC

von M. Windram, R. Morcom und T. Hurley

Zusammenfassung

'Zu den Vorteilen, die sich mit dieser (MAC-) Lösung erzielen lassen, gehören u.a. die Möglichkeiten des Bildfunkes mit erhöhter Bildschärfe mit dem Potential einer hochwertigen Darstellung auf Bildschirmen von vergrößerter Abmessung.' Diese Erklärung wurde im September 1981 in einer ersten Abhandlung der britischen Independent Broadcasting Authority gemacht, in welcher die MAC-

Lösung für den Satellitenfunk beschrieben wird.

Es wird darin ein fest umrissener Vorschlag auf einen MAC-Dienst von 'erhöhter Bildschärfe" (E-MAC) gemacht, und zwar in einer Art und Weise, die mit konventioneller MAC absolut kompatibel ist, sich aber die in die C-MAC-Spezifikation eingebaute Flexibilität zunutze macht. Der Vorschlag berücksichtigt die Möglichkeit von annähernd gleichen Bildseitenverhältnissen und Auflösungsvermögen wie bei dem 1125-zeiligen NHK-Fernsehsystem aber ohne das Erfordernis auf Funkfrequenz-Kanalbandbreiten, die in praktischer Form den Bildgunksendern in Europa womöglich während der nächsten 20-30 Jahre nicht zur Verfügung stehen werden.

Handelssichtgeräte für HiFi-Fernsehen

von C. A. A. J. Greebe, L. J. van de Polder und S. L. Tan

Zusammenfassung

Jedes neue Bildfunksystem muß in seiner Leistung auf das Vorhandensein von geeigneten Großschirm-Sichtgeräten bezogen sein — es hat wenig Sinn ein neues Sendesystem zu entwickeln, das ein größeres Auflösungsvermögen als von Heimsichtgeräten wiedergegeben werden kann offeriert oder welches das Auge bei den typischen Sichtweiten im Heim auf einem kleinen Bildschirm nicht imstande ist aufzulösen.

Somit wird die Verfügbarkeit von Großschirm-Sichtgeräten als ein Schlüsselfaktor für jeden Schritt in Richtung auf ein höherzeiliges System angesehen. In diesem Kapitel werden die wünschenswerten Merkmale von Großschirm-Heimsichtgeräten erörtert und die verschiedenen Optionen und praktischen Begrenzungen der heutigen Sichtgeräte betrachtet.

¿Por qué HDTV incompatible?

por T. Long

Resumen

Se indica los diversos requisitos para obtener televisión de 'alta definición', junto con las limitaciones de los actuales sistemas de televisión.

El enfoque convencional para la televisión de alta definición es aumentar el número de líneas del sistema de transmisión, con el consiguiente aumento de los requisitos de anchura de banda, y la incompatibilidad con sistemas actuales.

La llegada de la retransmisión directa vía satélite (DBS) empleando el formato MAC introduce la posibilidad de mayores mejoras para obtener un sistema compatible de 'definición extendida'. El mismo sería capaz de ofrecer la mejorada calidad de los sistemas de alta definición, pero sin incompatibilidad con el formato de 625 líneas o las propuestas corrientes para DBS.

Tratamiento de señales para televisión de más alta definición

por G. Tonge

Resumen

El sistema MAC ofrece mejoras en la calidad de la imagen comparado con los sistemas de subportadora ordinarios. Por medio de las técnicas de tratamiento de señales se puede mejorar todavía más, como se observa comparando el rendimiento obtenido con el método de 'definición extendida' MAC con el de los sistemas de 'alta definición'.

Definición extendida MAC

por M. Windram, R. Morcom y T. Hurley

Resumen

'Las ventajas que pueden obtenerse por este enfoque (MAC) comprenden las posibilidades de los servicios de definición extendida con potencial para presentación de alta calidad en pantallas de tamaño aumentado'. Esto fue consignado en el primer artículo publicado en septiembre de 1981 por la Independent Broadcasting Authority describiendo el enfoque MAC a la radiodifusión vía satélite.

Se hace una propuesta específica para un servicio MAC de 'definición extendida' (E-MAC) de un modo completamente compatible con el MAC convencional, pero explotando la flexibilidad inherente a la especificación C-MAC. La propuesta ofrece la posibilidad de obtener relaciones de forma y resolución próximas a las del sistema de televisión de alta fidelidad de 1125 líneas NHK, pero sin la necesidad de anchuras de banda de canal de R.F. no disponibles en la práctica para los radiodifusores europeos hasta dentro de 20-30 años.

Presentaciones visuales para televisión de alta fidelidad

por C. A. A. J. Greebe, L. J. van de Polder y S. L. Tan

Resumen

La capacidad de todo nuevo sistema de radiodifusión debe relacionarse con la disponibilidad de presentaciones visuales de gran pantalla. No tiene sentido diseñar un nuevo sistema de transmisión que ofrezca mayor resolución que la obtenida por las presentaciones domésticas, o que la vista sea incapaz de distinguir en pequeña pantalla a distancia de visión doméstica ordinaria.

La disponibilidad de presentaciones de gran pantalla se considera pues un factor esencial en cualquier proyecto de un sistema de más alta definición. Este artículo discute las características deseables de las presentaciones domésticas de gran pantalla y considera las diversas opciones y limitaciones prácticas de los dispositivos de presentación corrientes.

IBA TECHNICAL REVIEW

* Out of Print

The Independent Broadcasting System

The Independent Broadcasting Authority (IBA) is the central body responsible for the provision of Independent Television (ITV, including TV-am, and Channel 4) and Independent Local Radio (ILR) services in the United Kingdom. The IBA selects and appoints the programme companies; supervises the programme planning; controls the advertising; and builds, owns and operates the transmitters. Independent Broadcasting is completely self-supporting, financed by the sale of spot advertising time in the companies' own areas.

More information is contained in *Television & Radio 1984,* the IBA's guide to Independent Broadcasting (£3.90 from bookshops); or in *Broadcasting for Britain,* available free of charge from the Information Office, IBA, 70 Brompton Road, London SW3 1EY.